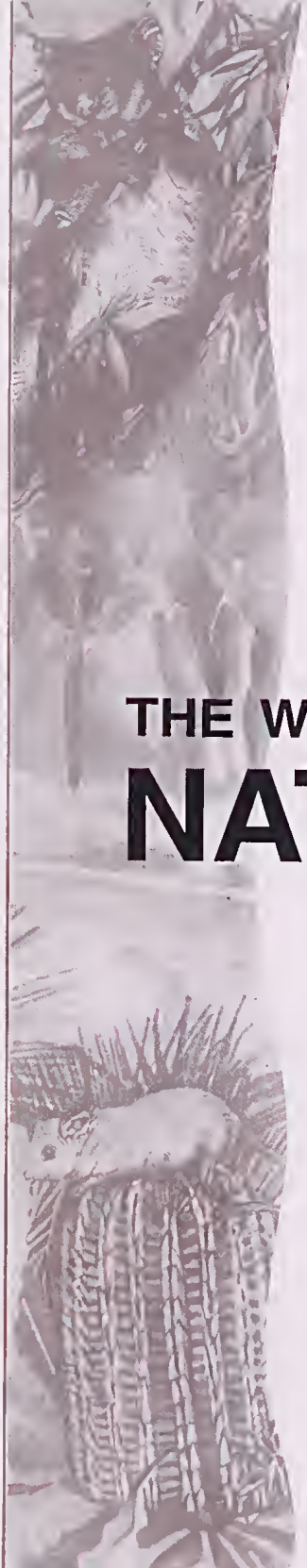

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EFFECT OF FIRE IN TORNDIRRUP NATIONAL PARK, SOUTH COAST, WESTERN AUSTRALIA

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ABSTRACT

A wildfire in 1997 burnt the central part of the Torndirrup National Park on the south coast of Western Australia. An existing fauna survey within the burnt area was extended to cover a four-year period after the fire, to study recolonisation by animals and regeneration of plants. One predominant banksia, the winter-flowering *Banksia quercifolia*, was mostly destroyed by the fire but regenerated from seed. The absence of its flowers in winter affected the numbers of the dependant Honey Possum at that time of year.

INTRODUCTION

Torndirrup National Park is situated on the south coast of Western Australia, south of Albany, and is predominantly banksia heath and woodland with a dense understorey of sword grass, *Lepidosperma* species. No permanent surface water exists during summer.

A survey of the terrestrial vertebrate fauna was carried out in the mid-1980s, using pitfall traps and Elliott traps (Smith 1990). This established that there was a rich fauna of small vertebrate species within the Park, including six small mammal species, five species of frogs and twenty species of reptiles. Amongst the mammals, the Honey Possum *Tarsipes rostratus* was particularly common, but also recorded were the Dibbler *Parantechinus apicalis*,

which had not been trapped since 1988, and the Mardo *Antechinus flavipes*.

Within the central heath-lands of the Park, the Oak-leafed Banksia *Banksia quercifolia* was the dominant banksia, providing not only food but also shelter for the many Honey Possums found in this banksia heath during winter (Smith 1991). Small sparse stands of Candle Banksia *Banksia attenuata* also occurred in the central third. Annual monitoring of the *Tarsipes* population, using the original pitfall traps, revealed that their numbers remained relatively constant over a ten-year period, as if they had established a climax.

Prior to a wildfire in January 1997, the heath lands had not been burnt for nearly thirty years. The last fire was recorded in 1969, the year the Park was declared. Thus the *B. quercifolia* were mature, with very few seedlings providing evidence of regeneration from seed. Dieback (*Phytophthora* infections) is present in the Park.

THE 1997 FIRE

The midsummer fire on 17 January 1997 initially burnt fiercely uphill, fanned by an east wind, and burnt 610 hectares of the northern centre of the Park, an estimated quarter of this area being granite outcrops (monadnocks) on which some animals may have survived the fierce radiant heat in crevices. The fire effectively destroyed most (>95%) of the old *B. quercifolia* plants in the Park and greatly altered the vegetation structure. Within the main trapping area, three counts of dead *B. quercifolia* plants revealed an average density of 150 plants per hectare in the deep sandy soils on which they grew best. Two days after the fire, gale-force winds dispersed the ash-beds so that in many areas only bare sand remained. Ten millimetres of rain fell on the third day. Devastating as the 1997 fire was, it provided an opportunity to study recolonization and regeneration of an area for which fauna records were available over the previous ten years. Friend (1993) reviewed the impact of fire on small vertebrates in woodlands and heathlands of temperate Australia, but with only one reference to Western Australia. Bamford (1986) conducted his work in *Banksia* woodland north of Perth but has described the responses of frogs and reptiles to fire in the same area (Bamford 1992; 1995).

METHODS

Vertebrate fauna were surveyed following the methods described for the original survey (Smith 1990). Four original sites (A, E, G, H) were on a north-facing slope, in sand, with 60 cm deep pitfall traps spaced at approximately 10 metres in lines. To these four was added Site J in April 1988. The

Table 1. Showing features of trapsites A, E, G, H and J.

Site	Number of pitfalls	Drift Fence	Distance from fire edge in metres	Predominant banksia *Banksia quercifolia*	*Banksia attenuata*
A	6	No	<100		+
E	13	Partly	400		+
G	9	No	400	+	
H	10	Yes	300	+	
J	9	Yes	600	+	

features of each site are summarised in Table 1. They were all affected by the 1997 fire. The plastic tops of the 60 cm deep pitfall traps melted and the drift fences were totally destroyed. By trimming off the melted top 2 to 5 cm of each trap *in situ* with an angle grinder, they were restored to full use again, though fractionally shorter, averaging 55 cm in depth. Drift fences were replaced. By April 1997 the monitoring was resumed, using these same sites and traps.

During the annual monitoring prior to the fire, traps were opened for a few days every four to six weeks, but for longer periods during the last quarter of each year (spring into summer), when more captures were generally recorded (See Table 2). To facilitate comparison of the data pre- and post-fire, where there is a normal seasonal bias, captures have been totaled quarterly (First quarter; January to March) for each year. Since the initial survey (Smith 1990), captures during the annual monitoring have been relatively constant, so four years before and after the fire, covering the period 1993 to 2000, have been considered adequate for comparison. For *Tarsipes* only, capture rates have been calculated and adjusted per 1000 trapnights, and the capture rates

Table 2. Total number of trapnights for sites A,E,G,H and J combined for each quarter for the years 1993–2000. Note the date of the fire.

YEAR	QUARTER				TOTAL
	1	2	3	4	
1993	60	489	285	1012	1846
1994	624	577	132	463	1796
1995	528	158	441	924	2051
1996	353	823	76	1202	2454
		FIRE – 17 JANUARY 1997			
1997	0	917	437	703	2057
1998	637	0	713	1215	2565
1999	411	466	368	730	1975
2000	638	830	454	1134	3056

for the same period have been shown for comparison.

From October 1997 to February 1998, pollen swabs were collected from *Tarsipes*, using the technique described by Wooller *et al.* (1984). Each animal was thoroughly sampled by rolling the gel around the muzzle as far back as the eyes, because charcoal still present from the fire tended to mask some of the pollen.

Captures of invertebrate animals were also recorded and observations made on their abundance.

Foxes *Vulpes vulpes* were controlled before and after the fire by the use of 1080 poison in eggs.

The regeneration of plants was studied using a 10 metre square quadrat, established in April 1997 in the centre of the trapping area. Growth and seedling counts of banksias were recorded at least once a year.

OBSERVATIONS AND RESULTS

During the first quarter after the fire, several small reptiles, *Ctenotus catenifer, Hemiergis peronii, Lerista microtis, Glaphyromorphus gracilipes* and one *Aprasia striolata* were encountered while restoring fence lines before trapping recommenced. Many would have survived the fire beneath the ground, as did one Bardick *Notechis curtus* in a pitfall trap closed with brush. A max-min thermometer in one pitfall trap, over which the fire passed, only recorded a maximum of 28° C, 50 cm beneath the surface.

Sticknest and bull ants, Formicidae, cockroaches *Blatta orientalis*, carab beetles, Carabidae and male Mouse Spiders *Missulena hoggii* were also regularly seen during the first and second quarters. Most sticknest ant nests were totally consumed, leaving craters 30 cm deep in the bare sand 48 hours post-fire, yet obviously many small nuclei of ants survived.

During the first winter post-fire (second and third quarters 1997), most of the traps at Site H flooded due to the raised water table (never having flooded before), so were closed with brush. This did not keep out frogs, many of which were caught.

Within the quadrat, two *Adenanthos* species (10 plants of *A. obovatus*; 34 *of A. cuneata*) grew from their lignotubers and flowered within 12 months. However 8 *Banksia quercifolia* were totally destroyed, but numerous seedlings at 5–12 leaf stage were recorded:

- 466 at ten months,
- 363 at twenty-three months,
- 159 at forty-one months (two with flowers),
- 69 at forty-seven months (30 – 40 cm high and showing vigorous new growth).

In deep sand it seems that surviving *Banksia quercifolia* seedlings may require up to four years establishing a deep root

system to reach the water table. At Site H, where the water table was nearer the surface, some seedlings attained 60 – 70 cm height with several flowers by 36 months. New growth from thicker branches of *Banksia attenuata* was evident by twelve months and flowers by the end of the second year, though later in the year than usual.

Surface coverage by regeneration was slow and estimated at 5% by the end of the second quarter, 15% by the end of the first year and still under 50% by the end of the fourth year, whereas prior to the fire, where the sword grass, *Lepidospermum* species, grew prolifically, they provided a dense thatched mat and 100% cover.

For the period 1993 to 2000, the total trapnights each quarter are presented in Table 2. The vertical arrow on subsequent charts indicates when the fire occurred. Since the fire, no trapping was carried out during two quarters, the first in 1997 immediately after the fire, and the second during the second quarter 1998. The total trapping effort per year averaged 2000 trapnights.

Total captures of the House Mouse *Mus musculus* per quarter at all sites are shown (Figure 1a).

Five species of amphibians occur in the Park and all were encountered during the second quarter (winter) after the fire. In decreasing order of abundance the five species were: *Crinia georgiana, Limnodynastes dorsalis, Heleioporus eyrei, Litoria moorei* and *L. adelaidensis*. Whereas *Crinia georgiana* is not normally considered a burrower, it could have survived beneath the ground as did the two burrowing species *Limnodynastes dorsalis* and *Heleioporus eyrei*. The two *Litoria* species have arboreal capabilities. Total frog captures per quarter are shown (Figure 1b).

Five species of small skinks that occur in the Park were all captured within twelve months of the fire. In decreasing order of abundance they were: *Hemiergis peronii, Lerista microtis, Glaphyromorphus gracilipes,, Ctenotus catenifer* and *Acritoscincus trilineatum*. Total small skink captures per quarter are shown (Figure 1c). The large Bobtail *Tiliqua rugosa*, many of which would have been killed in the acute phase, was only encountered twice, on both occasions at the wetter Site H.

Three *Notechis* species (*N. scutatus, N. curtus, N. coronatus*) were first seen in the last quarter of 1998, almost two years after the fire.

Total captures of adult and immature Coastal Dunnart *Sminthopsis griseoventer* per quarter at all sites are shown (Figures 2a; 2b). Immature dunnarts were only found in the first and fourth quarters. An unexpected dasyurid, an adult male Mardo *Antechinus flavipes*, was trapped in the second quarter of 2000 at Site G, where this species had not been recorded before. The few previous Mardos in the Torndirrup National Park had

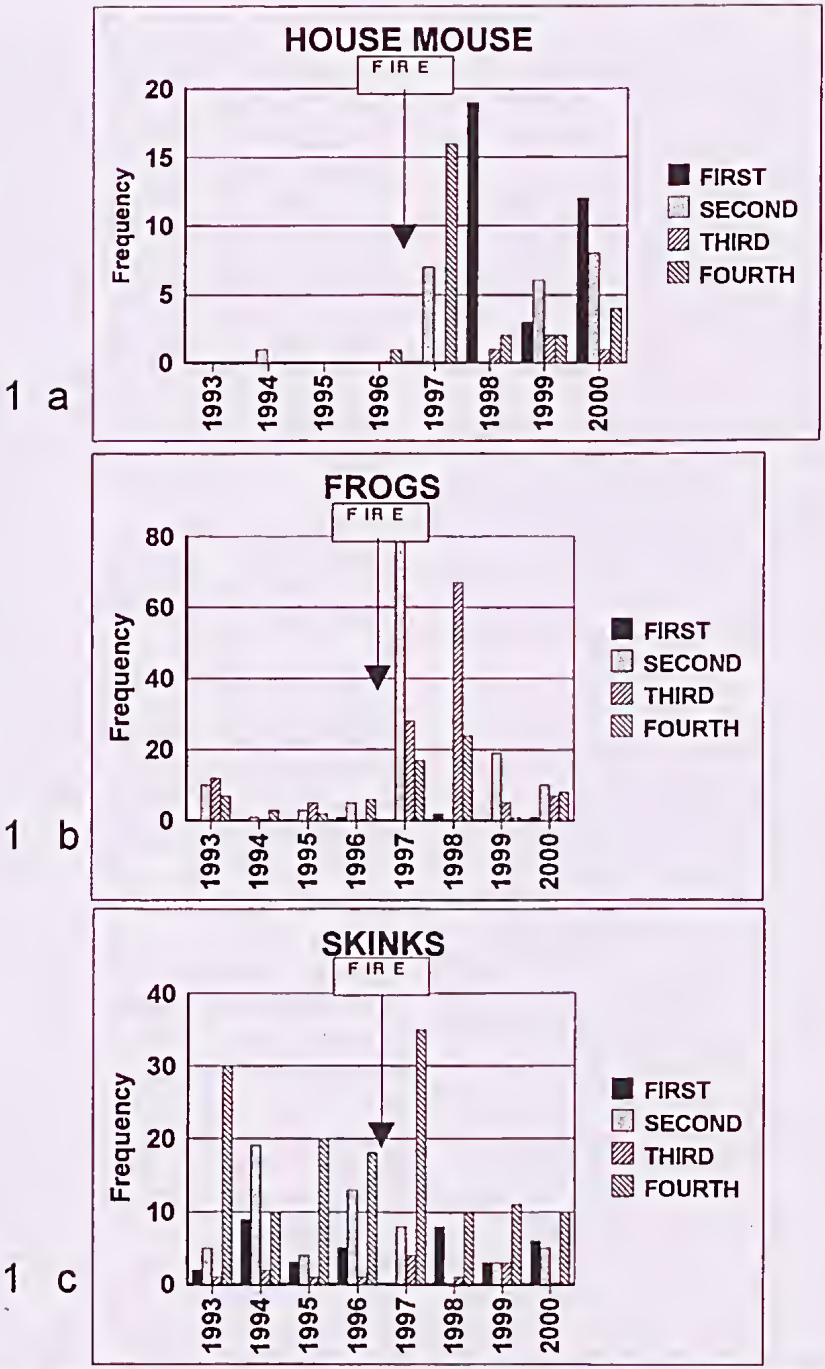

Figure 1. Showing total catches per quarter (1993–2000) of: a. House Mouse, b. Frogs (five species), c. Small skinks (five species).

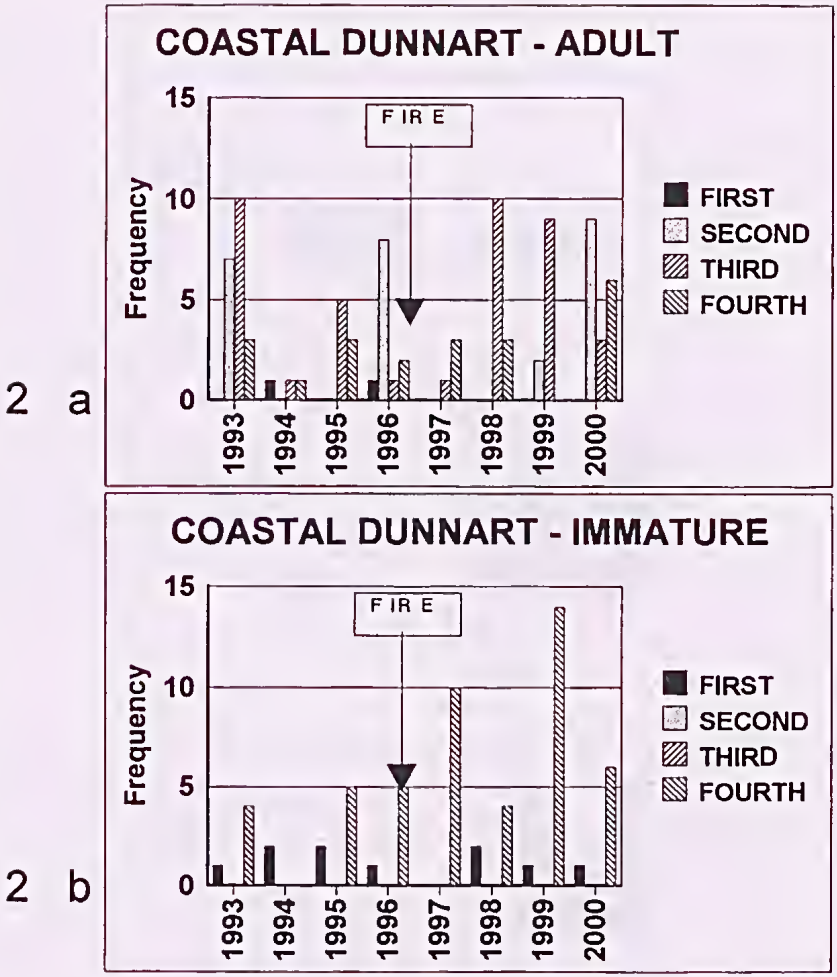

Figure 2. Showing total catches for each quarter (1993–2000) of Coastal Dunnart, showing adults and immatures.

been trapped in relict Karri forest.

Only seven Bushrats *Rattus fuscipes* were trapped in the first two years after the fire.

The first young Southern Brown Bandicoot *Isoodon obesulus* was not captured until 36 months after the fire at Site A, near the fire edge. Since only young bandicoots are caught in pitfall traps, the adults capable of jumping out, this would suggest that little breeding had occurred until three years after the fire.

The capture rates per quarter of Honey Possums over eight years at two sites (G & J) well in from

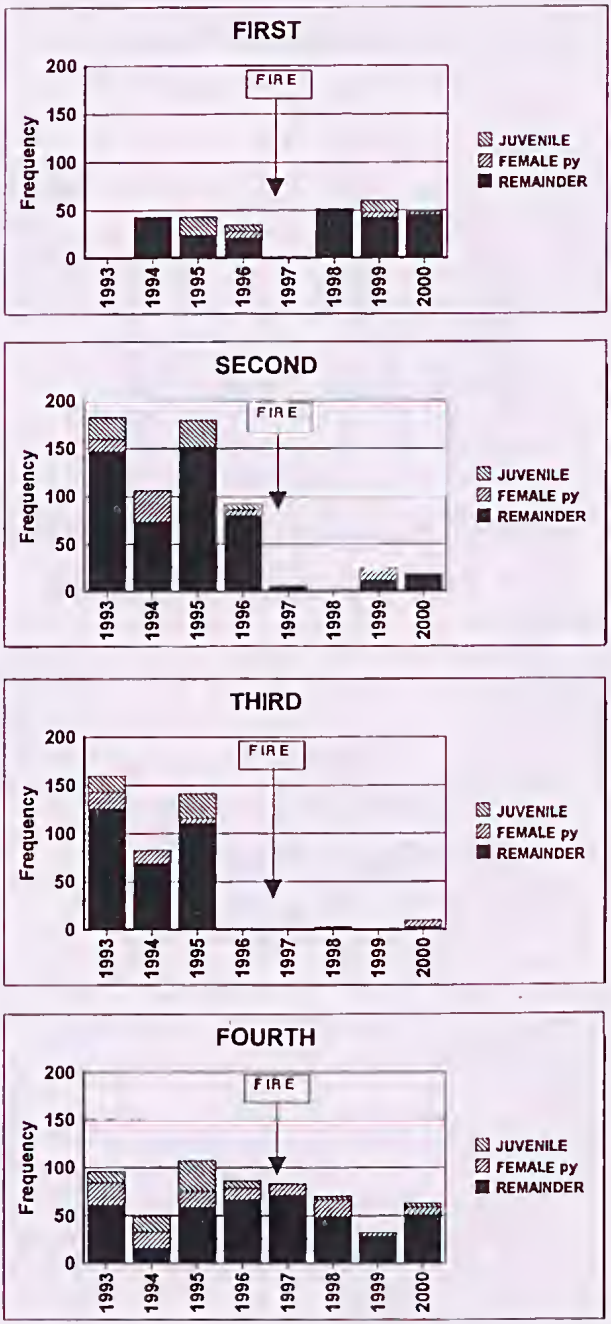

Figure 3. Showing capture rate per 1000 trapnights of Honey Possum (Sites G and J only) for each quarter (1993–2000), showing juveniles, females with pouched young (py) and the remainder (adult males and females).

the fire edge, are illustrated (Figure 3).

Pollen examination revealed abundant amorphous charcoal in many samples, yet stained pollen grains showed up clearly. Only light loads of pollen were found in 60% of the total samples taken. Eighteen of twenty-seven samples from sites G and J, well within the fire edge, had light loads of *Banksia* and *Adenanthos* pollens. No other pollens could be detected, although other species (Southern Cross *Xanthosia rotundifolia*, Drumsticks *Dasypogon bromeliifolius* and Lanolin Bush *Franklandia fucifolia*) were flowering.

DISCUSSION

The Bardick, found two days after the fire alive and uninjured beside a pit trap, probably fell victim to the many predatory or scavenging birds, including Australian Ravens, Australian Magpies, Laughing Kookaburras and Grey Currawongs which were encountered quartering the burnt area, or perhaps to the Rosenberg's Monitor which survived in its burrow beneath a charred bush not far away.

The fierce fire eliminated all but those species of vertebrate and invertebrate fauna with fossorial habits, yet the progression of recovery by recolonization and regeneration follows the predictions of Friend (1993).

During the acute impact phase, the increase in numbers of House Mice, a post-disturbance opportunist, was particularly evident in the second and fourth quarters of the first year, though not one was caught during the wet and cold third quarter. Their numbers rose to a peak in the first quarter of the second year, then declined. This is a well-recognised response.

The abundance of amphibians seen soon after the fire, particularly noticeable in the wetter, colder second and third quarters of each year suggested that their survival and recovery may have been enhanced by three factors, their ability to burrow, plentiful invertebrate food and the absence of predators, particularly snakes.

The numbers of smaller skink species reached their peak during the warmer fourth quarter of the first year, although ground cover was still scant and in spite of some possible losses from predation. There appeared to be no long-term impact on numbers, as already shown by Bamford (1995).

By the second year numbers of Coastal Dunnarts had returned to their pre-fire levels, because this species is a monoestrus spring breeder (Bamford 1986; Smith 1990), free-living young appearing consistently in mid-December each year. Young present in the last quarter of the first and second years after fire confirm that breeding had been successful. With the abundance

of skinks and invertebrate food immediately after the fire, dasyurid numbers could be expected to recover rapidly, once protective vegetation cover became established, yet some would also survive in old sticknest ant nests or burrows.

The few adult Honey Possums captured in good condition 400 – 600 metres inside the burnt area during the first six months were apparently pioneering colonists, yet not one was trapped or recaptured in the colder and wetter third quarter, though several were captured in the last quarter of the first year. By two years post-fire, Honey Possum capture rates were within the range of pre-fire capture rates in lst and 4th quarters but not during the winter, suggesting that they were making seasonal use of the burnt area yet had some reproductive capacity to recolonize, provided regeneration of some nectar-producing plants, notably *Adenanthos* species, had occurred as has been reported elsewhere (Bamford 1986).

During the second and third quarters (Figure 3) their recolonization was impaired by the absence of flowers on the Oak-leafed Banksia seedlings. From previous pollen swabbing carried out during the pre-fire period, this banksia was shown to be their preferred source of food during the winter when it flowers. Regenerated seedlings in deep sand take at least five years before there is much flower, a situation that is likely to be exacerbated if this obligate-seeding species is threatened by other factors, like Dieback, which may jeopardise its recovery.

A possible solution, which would benefit not only the long-term survival of this banksia but also the Honey Possum, is the patch burning *at an appropriate time of year* of small areas of this type of banksia heath to encourage regeneration from seed.

ACKNOWLEDGEMENTS

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A MOLECULAR GENETIC AND MORPHOLOGICAL APPRAISAL OF A DISTINCTIVE FORM OF THE SANDY INLAND MOUSE, *PSEUDOMYS HERMANNSBURGENSIS*

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SUMMARY

The molecular genetic techniques of allozyme electrophoresis and mitochondrial DNA sequencing were used to assess the genetic and taxonomic affinities of a "gracile" form of the Sandy Inland Mouse *Pseudomys hermannsburgensis* from the Pilbara region of Western Australia. Measurement of four external variables plus 26 cranial and dentary variables were also made to assess the nature of any morphological differences between the distinctive animals and typical *P. hermannsburgensis*. Individuals of each morphotype plus other reference specimens and species were genotyped at 53 allozyme loci and sequenced for a 307 base-pair portion of the mitochondrial *cytb* gene. While the most obvious differences between the two morphotypes involve external characters, there is some suggestion that the relative shape of the skull may also be partly diagnostic. Despite these morphological differences, the genetic data reveal no evidence that the two forms are genetically distinct from one another and thus demonstrate they are highly likely to be conspecific.

INTRODUCTION

Recent survey work in the Pilbara region of Western Australia has revealed several adult specimens of the Sandy Inland Mouse, *Pseudomys hermannsburgensis*, whose appearance is distinctive from other specimens in the region. These distinctive animals appear smaller and more gracile, comparative in size to a large *P. delicatulus*, when compared to animals displaying the typical appearance of an adult *P. hermannsburgensis*. Importantly, these gracile animals are sympatric with typical *P. hermannsburgensis*, thus ruling out the possibility that any morphological differences have resulted from the genetic

isolation of a regional subpopulation of *P. hermannsburgensis.*

Two hypotheses could account for these unusual animals, namely (1) they represent a previously-undocumented morphological variant within the species, or (2) they represent another, presumably new, species of *Pseudomys.* Given that several species described in the past 20 years were formerly included in *P.* "hermannsburgensis" (Breed 1995), any variant form of the Sandy Inland Mouse is clearly a prime candidate for consideration as a new species.

Distinguishing between these alternative explanations is best achieved using molecular genetic data to provide an independent assessment of the genetic affinities of the two forms. Of the many techniques available, allozyme electrophoresis and mtDNA sequencing are the most suitable and cost-effective molecular techniques (Avise 1994). The former can determine whether the two forms are members of the same biological species, whilst the latter can resolve the evolutionary affinities of the variant form amongst other related species of *Pseudomys* (to ensure that any "new" taxon does not turn out to be a variant of an already-described species).

Previous field workers have also recognised two morphotypes of *P. hermannsburgensis* in the field, (*pers. comm.* Norm Mckenzie, Ken Aplin, and Roy Teale), although unfortunately no aberrant specimens had tissues taken for molecular genetic analysis. However, during a survey in November 1998 at Brockman Mine in the Pilbara (22°18"S, 117 °17'E), several animals representing both the standard and gracile morphotypes were vouchered at the Western Australian Museum for both the preserved specimen and their frozen tissues. The chance to obtain molecular and morphological data from sympatric representatives of both forms provides the ideal opportunity to determine whether the gracile form is indeed a new species, as suggested by its morphological distinctiveness, or simply an unusual variant of the Sandy Inland Mouse. The purpose of this paper is to determine the taxonomic affinities of the two morphological forms using molecular genetic and morphological techniques.

METHODS

Specimens were trapped in the field using Elliott Traps or Pit Trap/fences. Animals were euthanased, numbered, and livers were immediately removed into liquid nitrogen. The animal was then preserved in 4% formalin before being washed and stored in 70% ethanol. Skulls were removed and cleaned for morphological comparison.

Morphological measurements

Given that, by definition, "unusual" morphotypic forms are

only rarely encountered in the field and even less commonly taken as vouchers, the small sample size (n=5) available for the gracile form (hereinafter referred to as *Pseudomys* sp. for convenience) precludes any comprehensive statistical analyses of the morphological data. This limitation of small sample size is further compounded by the fact that gender and adult age class differences can never be properly explored in any rare taxon (ie. *Pseudomys* sp.). As such, the best that can be achieved herein is a qualitative assessment of the morphological differences between the two forms, in combination with a basic Analysis of Variance for each individual character. In regard to the latter, it must be remembered that, due to the small sample sizes involved, the chance of a "type II" statistical error (i.e. falsely accepting the null hypothesis that the two forms do not differ significantly for a given character) remains unavoidably high in any univariate statistical test.

Only adult animals were included in this study. Animals were considered adult if they were reproductively mature and if skull sutures were fused. Two age classes were observed, based on dental differences; class 3 = mature adult with worn teeth and class 2 = adult with slight wear.on teeth. Although all five *Pseudomys* sp. available were males, both male (n=4-5) and female (n=3) *Pseudomys hermannsburgensis* were included in the morphological analyses to provide a more complete picture of morphological diversity in the "parent" taxon. The details of all animals subjected to morphological analysis are presented in Table 1.

External and cranial measurements of all specimens were made using digital callipers. Four external characters were measured, namely: HV, head vent length; TV, tail-vent length; PESL, pes length; and EARL, ear length (Table 2a). The following cranial measures were recorded (Table 2b), as outlined in Cooper *et al.* (2003): GL, greatest length; BD, braincase depth; IPW, interparietal width; BW, braincase width; ZW, zygomatic width; IW, interorbital width; NL, nasal length; NW, nasal width; BUW, bulla width; BL, braincase length; PL, palate length; M^1L, upper molar 1 length; M^3L, upper molar 3 length; M^1M^3, upper molar 1 to molar 3 length; APF, anterior palatal foramen; CIL, condyle to incisor length; and M_1M_3, lower molar 1 to molar 3 length. In addition, a series of extra cranial measurements, not used by Cooper *et al.* (2003), were taken: BUL, bulla length; WOB, width outside bullae; WIB, width between bullae; M^2L, upper molar 2 length; MTD, mesopterygoid distance; PTD, pterygoid distance; PTW, width of pterygoid at tip.

To qualitatively assess the extent to which the two forms were diagnosable using the morphological data, a separate Principal

Components Analysis (PCA) was performed on each of the external and cranial datasets. The statistical significance of any differences between the two forms was assessed for each variable by Analysis of Variance (ANOVA). Both procedures were carried out using the computer program *STATISTICA*.

Allozyme analysis

Frozen livers were available in the tissue collections of the Western Australian and South Australian Museums. Four specimens of *Pseudomys* sp. from two locations were available for molecular analysis. These were compared to 13 typical *Pseudomys hermannsburgensis* taken from six locations, including two sites where both forms co-exist. Single specimens of *P. bolami* and *P. chapmani*, two species previously considered conspecific with *P. hermannsburgensis*, were also included. The details of all specimens screened are contained in Table 1.

Allozyme electrophoresis was undertaken on cellulose acetate gels according to the principles and procedures detailed in Richardson *et al.* (1986). A total of 53 loci displayed sufficient activity and resolution after electrophoresis to allow allozymic interpretation. Details of the locus abbreviations are presented in Georges and Adams (1992) whilst the nomenclature used to refer to loci and allozymes follows Adams *et al.* (1987). The statistical significance of any differences in allozyme frequency between the two morphotypes was assessed using the computer program GENEPOP (Raymond and Rousset 1995).

mtDNA sequencing

Two individuals of the variant morphotype plus one typical *P. hermannsburgensis* were sequenced for a 307 base-pair portion of the cytochrome-b (*cytb*) mitochondrial gene, according to standard protocols (Hillis *et al.* 1996). These sequences were compared to an existing *cytb* database previously generated in our laboratory and comprising *P. hermannsburgensis* plus its near relatives. The data were analysed both by eye and by constructing a neighbour-joining tree from the Jukes-Cantor genetic distance matrix, using the computer program MEGA (Kumar *et al.* 1993). Table 1 provides details of which animals were included in the mtDNA study.

RESULTS

External morphology

From initial comparison of the bodies of the two morphs, the *Pseudomys* sp. individuals, though fully reproductively mature with descended testes and epididymis, were obviously smaller than fully mature males of *P. hermannsburgensis*, even in sympatry (Brockman Mine). There, a mature male *P.*

Table 1. Details of all specimens used in this study. Code for Accession Numbers: WAMM = Western Australian Museum, SAMM = South Australian Museum, AMSM = Australian Museum; ABTC = Australian Biological Tissues Collection. Code for Data column: A = allozymes, S = skull measurements, E = external measurements, D = mtDNA sequence.

Accession Number	Taxon	Data	Locality	Latitude	Longitude
WAMM52452	*Pseudomys* sp?	A,S,E	Brockman Mine, WA	22°18'38"	117°19'19"
WAMM52437	*Pseudomys* sp?	A,S,E,D	Brockman Mine, WA	22°17'31"	117°18'03"
WAMM44138	*Pseudomys* sp?	A,E,D	Karratha, WA	20°40'16"	117°04'52"
WAMM41305	*Pseudomys* sp?	A,S,E	Karratha, WA	20°40'16"	117°04'52"
WAMM52371	*Pseudomys* sp?	S,E	Cape Preston, WA	21°03'57"	116°08'57"
WAMM52425	*P. hermannsburgensis*	A,S,E,D	Brockman Mine, WA	22°24'51"	117°21'18"
WAMM52411	*P. hermannsburgensis*	A,S,E	Brockman Mine, WA	22°17'31"	117°17'56"
WAMM52410	*P. hermannsburgensis*	A	Brockman Mine, WA	22°18'39"	117°18'40"
WAMM44139	*P. hermannsburgensis*	A	Karratha, WA	20°40'16"	117°04'52"
WAMM41304	*P. hermannsburgensis*	A,S	Karratha, WA	20°37'00"	117°10'59"
WAMM41801	*P. hermannsburgensis*	A,S	Barlee, WA	23°24'41"	115°53'39"
WAMM41813	*P. hermannsburgensis*	A,S,E	Barlee, WA	23°24'41"	115°53'39"
WAMM41833	*P. hermannsburgensis*	A,S,E	Barlee, WA	23°04'46"	115°47'27"
WAMM41837	*P. hermannsburgensis*	A	Barlee, WA	23°06'46"	116°00'28"
WAMM43170	*P. hermannsburgensis*	A,E	Nifty Mine, WA	21°40'00"	121°35'00"
WAMM48513	*P. hermannsburgensis*	A,S,E	Newman, WA	23°20'00"	119°34'00"
WAMM48514	*P. hermannsburgensis*	A,S,E	Newman, WA	23°20'00"	119°34'00"
SAMM18754	*P. hermannsburgensis*	A	Wallatinna, SA	27°25'00"	133°24'00"
SAMM14004	*P. hermannsburgensis*	D	Coongie Lakes, SA	27°08'37"	140°05'23"
AMSM25377	*P. hermannsburgensis*	D	Gerara Station, NSW	29°12'00"	146°15'00"
AMSM25376	*P. hermannsburgensis*	D	Gerara Station, NSW	29°12'00"	146°15'00"
ABTC28759	*P. hermannsburgensis*	D	Tanami Desert, NT	19°16'00"	132°40'00"

SAMM17273	*P. bolami*	A	Andrew Dams, SA	33°35'00"	139°55'00"
ABTC67582	*P. bolami*	D	Brachina Gorge, SA	31°20'00"	138°32'00"
ABTC13341	*P. bolami*	D	Balcanoona Station, SA	30°36'35	139°26'37"
WAMM47645	*P. chapmani*	A	Newman, WA	23°29'00"	120°12'00"
WAMM34297	*P. chapmani*	D	Woodstock Station, WA	21°41'45"	119°03'15"
WAMM29449	*P. chapmani*	D	Woodstock Station, WA	21°35'15"	119°05'05"
SAMM18804	*P. australis*	D	Three Mile Well, SA	29°43'47"	137°22'33"

hermannsburgensis collected from site NA52 on 22 November 1998, weighed 11g, whereas a mature male *Pseudomys* sp. collected at the same site on the previous day weighed 8.6g (20% lighter). The *Pseudomys* sp. was physically small and gracile, more like *P. delicatulus* than *P. hermannsburgensis*. The pelage of the *Pseudomys* sp. was similar to that of *P. hermannsburgensis*. Although both were sympatric in the sense of being collected at the same site, it was not possible to determine if they were truly "syntopic" i.e. occupying the same micro-habitat.

A PCA on the external variables is presented in Fig 1a). As the presence of a missing value in one of the *P. hermannsburgensis* specimens (WAMM41833; Table 2a) was causing this specimen to appear as a significant outlier (from both *Pseudomys* sp. and the other *P. hermannsburgensis* specimens), this specimen was omitted from the final analysis. The PCA qualitatively demonstrates the distinctiveness of the four specimens of *Pseudomys* sp. when compared to typical *P. hermannsburgensis*, both male and female. Interestingly, the first Principal Component is heavily influenced by the variables HL and PESL, despite the most striking dichotomy in the raw data being found in the variable EARL (Table 2a). This observation is supported by ANOVA on the four individual characters, in which only EARL showed a statistically-significant

difference between the two morphotypes (p=>0.01 for all adult males).

Cranial morphology

From an initial observation of skulls, the cranium in *Pseudomys* sp. appears to be more rounded, the upper molars narrower, the molar row shorter, the bullae less inflated though wider, the anterior palatal foramen reaches

Table 2a. External measures for the four *Pseudomys* sp. and seven *P. hermannsburgensis* examined. Code for sex: 1 = male, 2 = female. Code for age class: 2 = adult, slight wear on teeth, 3 = mature adult, worn teeth. A dash (-) indicates a missing value.

Animal	Form	Sex	Age	HV	TV	PESL	EARL
M44138	sp	1	2	58.4	73.5	14.9	9.1
M41305	sp	1	2	56.4	69.9	16.2	8.2
M52437	sp	1	2	56.7	71.8	16.5	9.0
M52452	sp	1	2	55.9	74.1	15.7	7.6
M43170	Ph	1	2	48.0	79.0	16.7	11.7
M52411	Ph	1	2	64.0	90.0	17.4	10.2
M41833	Ph	1	3	65.0	-	14.8	10.2
M48514	Ph	1	3	63.5	79.0	16.0	10.6
M48513	Ph	2	3	63.0	80.0	16.5	12.3
M41813	Ph	2	3	61.6	72.5	16.5	12.5
M52425	Ph	2	3	62.0	77.7	16.7	10.9

Table 2b. Skull measures for the four *Pseudomys* sp. and eight *P. hermannsburgensis* examined. Codes as for Table 2a.

Animal	Form	Sex	Age	GL	BD	IPW	BW	ZW	IW	NL	NW	BUL	BUW	WOB
M41305	sp	1	2	20.67	7.37	8.03	10.32	10.64	3.22	7.01	2.46	5.21	4.85	10.08
M52437	sp	1	2	21.68	7.04	6.99	10.01	10.60	3.14	7.20	2.37	5.04	4.70	9.92
M52452	sp	1	2	19.79	6.53	6.93	-	10.12	3.41	6.89	2.54	4.86	3.70	9.77
M52371	sp	1	2	21.71	7.62	6.50	10.54	11.14	3.51	6.99	2.56	5.21	4.70	10.46
M41304	Ph	1	3	22.62	6.91	7.60	10.50	11.17	3.51	8.48	2.64	5.64	5.07	10.71
M52411	Ph	1	2	21.86	7.30	7.05	10.25	10.81	3.58	7.26	2.52	5.38	4.78	10.07
M41801	Ph	1	2	19.83	7.05	7.63	10.31	11.07	3.36	6.72	2.62	4.95	4.56	9.85
M41833	Ph	1	3	22.06	6.67	7.56	10.07	10.91	3.55	7.32	2.60	5.12	4.70	10.21
M48514	Ph	1	3	21.57	7.38	8.31	10.46	11.51	3.36	7.95	2.41	5.58	5.28	10.75
M48513	Ph	2	3	-	7.21	8.25	10.52	11.21	3.52	7.71	2.63	5.33	4.98	10.26
M41813	Ph	2	3	22.84	6.59	7.64	10.28	10.79	3.50	8.07	2.65	5.49	4.67	10.81
M52425	Ph	2	3	22.41	6.98	7.39	10.06	10.65	3.41	7.91	2.47	5.26	4.96	10.29

the anterior end of upper molar 1 (as opposed to not reaching the start of the molar row) and the pterygoids appear to be more flared and wider at the tips than that of an average *P. hermannsburgensis*.

A PCA on the skull variables (Fig 1b) indicates that while two of the four *Pseudomys* sp. have moderately distinctive scores at Principal Component 1, the other two specimens lie squarely within the *P. hermannsburgensis* cluster. Thus there is no strong indication that the two morphotypes show any qualitative differences in skull characteristics above and beyond the variance displayed within each morphotype. This conclusion is backed up by ANOVA on individual characters, which did not reveal any statistically-significant differences between the two forms. Clearly a much larger sample size is required for *Pseudomys* sp. before a definitive answer on comparative skull morphology can be given.

Allozyme analysis

Thirty-five of the 52 loci used in this study were variable, displaying between two and four alleles. The remaining seventeen loci (*Ap-3, Ca-1, Est, G6pd, Gdh, Gldh, Glo, Got-1, Gpx, Hb, Idh-2, Lap, Mdh-2, Ndpk, Pgam, Pgk,* and *Pk-2*) were monomorphic. Table 3 presents the allozyme profiles for all 19 *Pseudomys* at the 35 variable loci.

The two morphotypic forms of the Sandy Inland Mouse share alleles at all loci. This contrasts markedly when either is compared with the other two species examined. Thus *P. bolami*, a species closely-related to *P. hermannsburgensis* and until recently considered to be conspecific (Kitchener *et al.* 1984), displayed

WIB	BL	PL	M1L	M2L	M3L	M1W	M1M3U	M1MI	MTD	PTD	PTW	APF	CIL	M1M3L
1.35	17.44	11.10	1.72	1.05	0.78	1.07	3.53	4.50	1.01	0.99	0.54	3.90	12.46	3.19
1.14	16.68	10.20	1.55	0.50	0.97	1.06	3.16	4.42	0.97	0.80	0.45	3.29	12.95	2.93
1.21	17.03	10.18	1.84	0.99	0.79	1.18	3.37	4.42	0.95	-	0.75	3.74	11.80	2.80
1.75	17.95	11.22	1.76	0.98	0.53	1.07	3.48	4.53	0.95	1.30	0.58	3.74	11.98	3.20
1.27	18.74	11.63	1.84	1.03	0.77	1.11	3.44	4.70	1.22	0.96	0.47	3.42	13.45	3.15
1.12	18.07	11.12	1.77	1.14	0.73	1.16	3.43	4.56	0.74	1.06	0.51	3.73	12.97	3.33
1.24	16.24	10.15	1.65	1.12	0.70	1.04	3.41	4.27	0.90	0.96	0.55	4.08	10.90	3.15
1.33	18.18	11.08	1.91	1.01	0.67	1.13	3.42	4.70	1.06	1.32	0.43	3.19	13.05	3.14
1.44	17.76	11.02	1.72	0.98	0.71	1.11	3.41	4.82	1.01	1.25	0.36	3.77	12.93	3.06
1.24	17.35	11.12	1.82	1.15	0.59	1.15	4.77	4.78	0.92	1.04	0.60	3.82	12.81	3.31
1.26	10.59	11.65	1.78	1.07	0.82	1.12	3.49	4.58	1.08	1.12	0.48	3.93	13.83	3.33
1.30	18.32	10.95	1.83	0.97	0.76	1.13	3.44	4.66	1.14	1.07	0.38	4.05	13.38	3.37

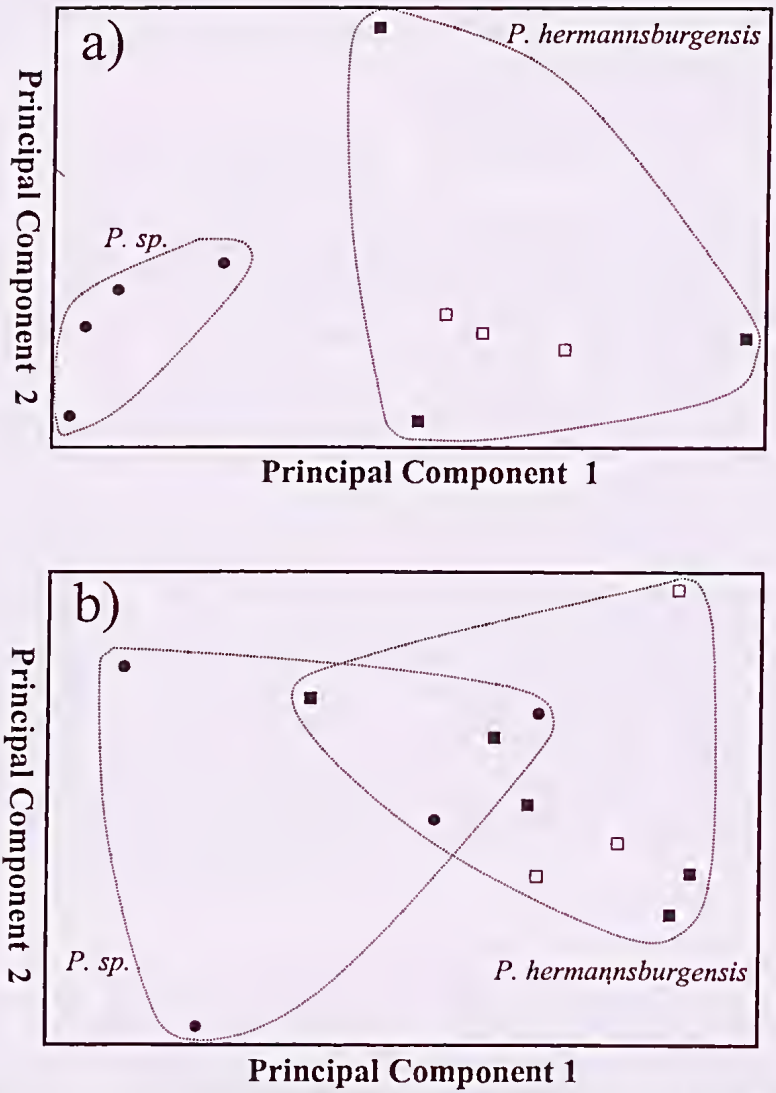

Figure 1. Principal Component Analysis of a) external and b) skull measures. Each animal has been plotted for their individual scores at the first two principal components extracted. Legend for specimens: closed circles = *P.* sp., closed squares = male *P. hermannsburgensis*; open squares = female *P. hermannsburgensis*. Specimen WAMM41833 was excluded from analysis a) due to the distortion caused by a missing value (see text for details).

fixed differences at 18% of loci (data in Table 3), and *P. chapmani* (once also included in *P. hermannsburgensis*; see Kitchener 1980) differs from both *P. hermannsburgensis* and *P. bolami* at 40-42% of loci examined. All species of *Pseudomys* examined to

Table 3. Allozyme profiles at 35 variable loci for the 19 *Pseudomys* examined. Identified by museum number and abbreviated taxon.

	Psp				*Pherm*													*Pbol*	*Paust*
Locus	52452	52437	44138	41305	52425	52411	52410	44139	41304	41801	41813	41833	41837	43170	48513	48514	18754	17273	47645
Acp	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	ab
Acyc	b	b	b	b	bc	bc	b	b	b	b	b	b	b	bc	b	b	b	bc	a
Ada	a	a	b	ab	a	a	a	ab	a	ab	a	a	a	a	ab	ab	a	a	b
Adh-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	c
Adh-2	ab	ab	b	b	b	b	b	b	b	b	b	b	b	b	b	b	ab	b	b
Ak-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
Ak-2	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	ab	c
Alb	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	b	a
Ap-1	b	b	b	b	b	b	b	ab	b	b	b	b	b	b	b	b	b	b	b
Ap-2	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a	c
Ca-2	b	b	ab	b	b	b	b	b	b	b	b	b	ab	b	b	b	b	b	c
Dia	b	b	b	b	b	ab	b	b	b	b	b	b	b	ab	ab	b	b	b	a
Enol	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	b	a
Fdp	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a	c
Fum	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b
Gda	b	b	b	b	b	b	b	b	b	b	b	b	b	ab	b	b	b	ab	b
Got-2	bd	bd	b	b	b	b	d	b	b	b	b	bd	b	b	bd	bd	bd	c	a
Gpi	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	b
Gpt	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b
Hbdh	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b
Idh-1	a	a	a	a	a	a	a	bc	a	cd	c	ac	a	a	a	a	a	a	a
Ldh	b	b	ab	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Mdh-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	ab
Me	a	a	a	a	a	a	a	a	ab	a	a	a	a	a	a	a	a	a	c
Mpi	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	c	a
Np	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	ab	b
PepA	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a
PepD	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	ab
6Pgd	b	b	b	b	b	b	b	b	b	b	b	bc	b	b	b	b	b	a	d
Pgm-1	a	ab	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
Pgm-2	c	c	c	c	c	c	c	c	c	c	c	ac	ad	c	c	c	c	c	bc
Pk-1	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b
Sod	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a
Sordh	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a
Tpi	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b

date have been diagnosable from one another using allozyme data (Baverstock *et al.* 1981).

Table 4 summarizes the allozyme frequencies for each morphotype at the 14 loci polymorphic within the Sandy Inland Mouse. The two morphotypes have

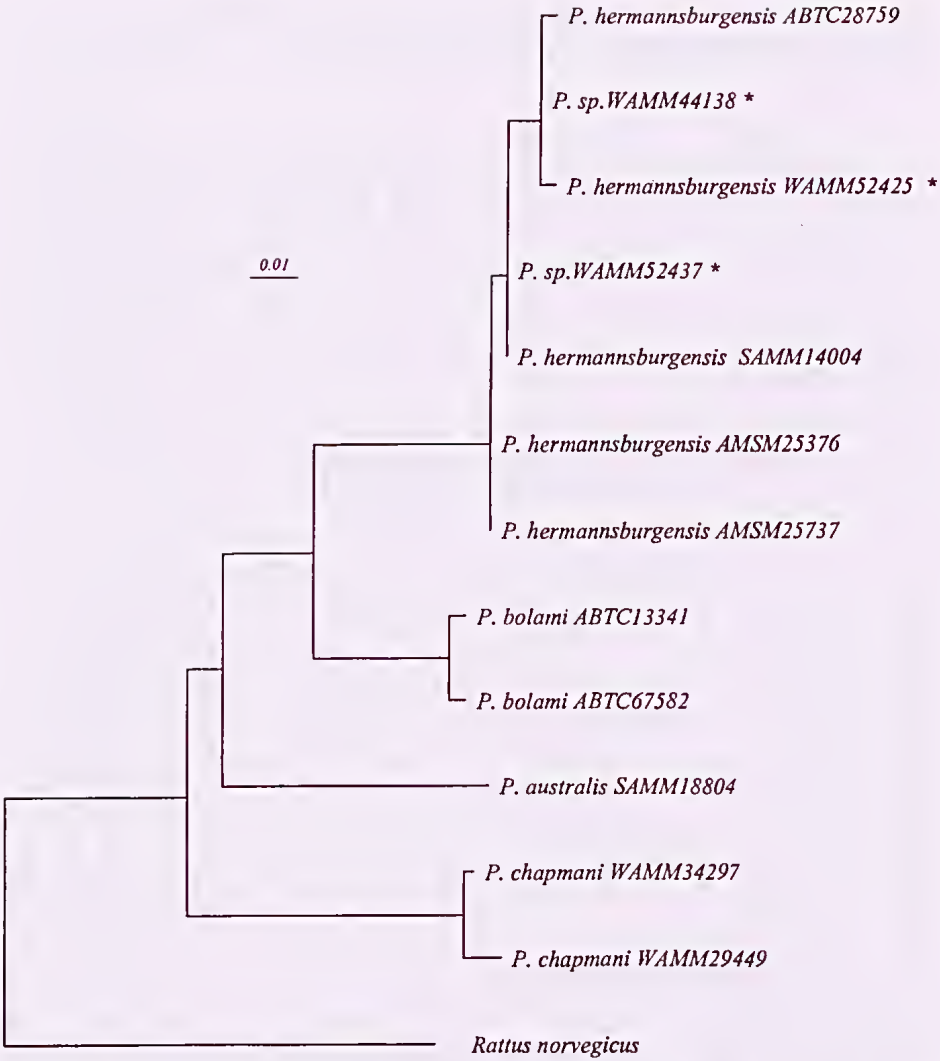

Figure 2. Neighbour-joining tree for the sequence data of Table 5, rooted using *Rattus norvegicus* as an outgroup. The sympatric *P.* sp. and *P. hermannsburgensis* animals are asterisked. The scale bar represents a Jukes-Cantor genetic distance of 0.01.

similar allozyme frequencies at all loci (maximum difference in allele frequency = 27% for *Idh-l*^{a}), and none of these differences were statistically-significant at the p = 0.05 level. Thus the two forms are allozymically indistinguishable from one another.

mtDNA sequencing

Table 5 compares the mtDNA sequence data for the two

Table 4. A comparison of allozyme frequencies between the two morphotypes. Where an allozyme is not fixed, the percentage frequency of each allozyme is shown as a superscript. Total number of haploid genomes shown in brackets. All comparisons are non-significant based on calculating an exact probability for the appropriate M x N contingency table. (Raymond and Rousset 1995).

Locus	*Pseudomys* sp. (n=8)	*P. hermannsburgensis* (n=26)
Acyc	b	b^{88},c^{12}
Ada	a^{63},b^{37}	a^{85},b^{15}
Adh-2	b^{75},a^{25}	b^{96},a^{4}
Ap-1	b	b^{96},a^{4}
Ca-2	b^{87},a^{13}	b^{96},a^{4}
Dia	b	b^{88},a^{12}
Gda	b	b^{96},a^{4}
Got-2	b^{75},d^{25}	b^{77},d^{23}
Idh-1	a	a^{73},c^{19},b^{4}.d^{4}
Ldh	b^{87},a^{13}	b
Me	a	a^{96},b^{4}
6Pgd	b	b^{96},c^{4}
Pgm-1	a^{88},b^{12}	a
Pgm-2	c	c^{88},a^{8},d^{4}

Pseudomys sp. and one *P. hermannsburgensis* analyzed in this study against a number of reference sequences of *P. hermannsburgensis* plus three other congeneric species (*P. bolami*, *P. chapmani*, and *P. australis*). The three test sequences are all very similar, both to one another (only three variable sites) and to the reference specimens of *P. hermannsburgensis* (a maximum of four differences). In contrast, all seven Sandy Inland Mouse sequences differ from the *P. bolami* reference specimens at 20 or more sites (15 of which are fully-diagnostic between these two sibling species). The reference sequences for *P. chapmani* and *P. australis* are even more divergent.

Figure 2 presents a phylogram of the mtDNA sequences. As shown, the genetic affinities of all three Pilbara specimens clearly lie within *P. hermannsburgensis*, with the four described species all belonging to separate, well-defined lineages. This general pattern of within-species similarity and between-species distinctiveness has been consistent for all species of *Pseudomys* sequenced thus far for this portion of the *cytb gene* (Steve Donnellan, Evolutionary Biology Unit; unpublished).

DISCUSSION

The molecular genetic data reveal no evidence that the four specimens of the variant morphotype examined herein represent a species of *Pseudomys* distinct from *P. hermannsburgensis*. These specimens displayed molecular genetic profiles indistinguishable from those of other *P. hermannsburgensis*, both in sympatry and from several points across its geographic range. The inclusion of both allozyme and mtDNA datasets ensures that this is a very comprehensive assessment of genetic identity.

While this gracile form almost certainly does not represent a new biological species, our morphological analyses support

Table 5. Summary of the variable nucleotide positions in a 307 base-pair fragment of the mitochondrial *cyt-b* gene. Shown in bold are the three sequences generated in this study, compared to a selection of reference sequences taken from an existing Evolutionary Biology Unit database. (. = same base as for *P. australis* SAMM18804; ? = could not be determined)

	Nucleotide Position		
	1 111111111111111111	222222222222222222222223	
	11122233344555677890	00112233344568889999	00122233445555666778889900
Animal	47034568034030681094 40	39251737928101571 67	58136904170679038140395 81
P. australis SAMM18804	CCT?TCCATTTCCCCACTTTCA	CCCCCCCCACTGTTTGTTG	AATCTCTTACTTCACTTATCTTCTC
P. chapmani WAMM34297	TTCA.T.GC.C...T.TC....	.TTT..ATGTCACCCACCA	..A.CT..TTCAACT.CC...CA.A
P. chapmani WAMM29449	TTCA...GC.C...T.TC....	.TTT..ATGTCACCCAC.A	..A.CT..TTCAATT.CC...CA.A
P. bolami ABTC67582	..AC......CTT.T..CC...	.T..TTTT...ACC.A...	GGA.C.....CAAT.C.CCT.C.C.
P. bolami ABTC13341	..AC......CTT.T..CC...	.T..T.TT...ACC.A...	GGA.C..C..CAAT.C.CCT.C.C.
P. hermannsburgensis SAMM14004	..ACC.T....TTTT.TC.CTG	TT.TT.TT...AC..AC..	..AT......CAAC.C.CC.CC.C.
P. hermannsburgensis AMSM25377	..ACC....A.TTTTGTC.CTG	T..TT.TT...AC..AC..	..AT......CAAC.C.CC.CC.C.
P. hermannsburgensis AMSM25376	..ACC.T....TTTT.TC.CTG	.T.TT.TT...AC..AC..	..AT......CAAC.C.CC.CC.C.
P. hermannsburgensis ABTC28759	..ACC.T....TTTT.TC.CTG	.T.TT.TT...AC..AC..	..AT......CAAC.C.CC.CC.C.
P. *hermannsburgensis* WAMM52425	**..ACC.T....TTTTGTC.CTG**	**T..TT.TT...AC..AC..**	**..AT..C...CAAC.C.CC.CC.C.**
P. *sp.*WAMM52437	**..ACC.T....TTTT.TC.CTG**	**TT.TT.TT...AC..AC..**	**..AT......CAAC.C.CC.CC.C.**
P. *sp.*WAMM44138	**..ACC.T....TTTTGTC.CTG**	**T..TT.TT...AC..AC..**	**..AT......CAAC.C.CC.CC.C.**

the notion that it is genuinely distinctive in external appearance when compared to typical *P. hermannsburgensis* from the Pilbara region and elsewhere. This distinctiveness is manifested in three of the four external characters examined, with gracile specimens being generally smaller, more slender-footed, and possessing relatively shorter ears. Despite no unequivocal indications that the skulls of these gracile animals were distinctive, there was a suggestion that subtle shape differences may become apparent if larger sample sizes had been available.

Within-species morphological variability features in most mammals. Such variability is most commonly encountered when comparing different populations, but nevertheless can and does occur within a population or region. Where such variability is marked and discontinuous, it may appear to mimic the presence of two or more morphologically-distinct species. This appears to be the case for *Pseudomys hermannsburgensis* in the Pilbara region of Western Australia. Elsewhere in Australia, other variant forms of what is presumably *P. hermannsburgensis* have been noted, involving both larger animals (*pers. comm.* Fred Ford) and animals which appear intermediate between *P. hermannsburgensis* and *P. bolami* (*pers. comm.* Cath Kemper). It remains to be seen whether these unusual animals are indeed simply morphotypic variants of the Sandy Inland Mouse, or whether some represent new taxa or hybrids with other species of *Pseudomys*. The present study highlights the advantages of using molecular genetic data to address the taxonomic identity of such animals and reinforces the need for voucher specimens and their tissues to be lodged with an appropriate museum.

We can only speculate as to the reasons why there are two discrete morphotypes of the Sandy Inland Mouse in the Pilbara. Perhaps these smaller, fully mature animals represent the consequences of a localized population response to the occasional good season by a small number of animals becoming reproductively mature at a much earlier stage and size. Alternatively, there may exist at low frequency one or more "partial-dwarfism" alleles among the various genes which influence growth in the *P. hermnannsburgensis* of that region. If these alleles are recessive and at low frequency in the population, then only a very small number of adults would display the "partially-dwarfed" phenotype. Such a situation occurs for example in laboratory rats (*Rattus norvegicus*), where mutant recessive alleles at four different genes are capable of producing fertile dwarf adults which range between 30-70% of normal adult body size (Hedrich 1990). Whatever the reason, it is clearly

important that taxonomists remain open to the reality that not all novel and distinctive morphological variants must automatically represent new species.

Of course the converse can occasionally be true, in that there are instances where different, morphologically-distinguishable species cannot unequivocally be diagnosed by molecular genetic analysis (Avise 1994; Richardson *et al.* 1986). However, such situations are generally limited to particular organismal groups which use visual cues for mate recognition (eg birds), to allopatric sister species, or to genetic analyses which are not comprehensive (i.e. only mtDNA data gathered, or only a small number of allozyme loci examined). As none of these three caveats applies to the present study, we are confident that the genetic diagnosis provided herein is valid. Nevertheless, such a conclusion can never deny the reality that genetically-determined differences in a small number of the genes which control morphology may be the only differences which characterize and therefore diagnose closely-related species. Thus, morphological data will always remain an essential component of any assessment of the taxonomic status of individuals and populations, both as a source of potential genetic markers of the speciation process, as well as the means by which taxa are formally described and subsequently diagnosed.

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VERTEBRATE FAUNA OF THE EASTERN GROUP, ARCHIPELAGO OF THE RECHERCHE, WESTERN AUSTRALIA

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ABSTRACT

The Eastern Group of the Archipelago of the Recherche consists of ten named islands, three named rocks and numerous unnamed islets and rocks. It is the most easterly group of islands in the Archipelago and the least known scientifically because of its remoteness. Brief visits by earlier naturalists and more intensive visits by us in the 1980's and 1990's have recorded a combined total of 45 species of birds, 4 mammals and 10 reptiles from seven of the ten islands (Anvil, Daw, Ford, New Year, Pointer, Six Mile and Spindle Islands). Three islands (Rodondo, Whaleback and Cranny Islands) have not been visited by naturalists. Data on each species are presented.

INTRODUCTION

The islands of the Archipelago of the Recherche off the southern Western Australian coast stretch for over 230 kilometres from about longitude 121°30' (just west of Esperance) east to longitude 124°10' and up to 60 km offshore in the west (Termination Island in 34°28'S, 121°59'E) and 30 km offshore in the east (Daw Island in 33°51'S, 124°04'E). There are about 105 islands and 1500 islets in the Archipelago, the largest and best vegetated being Middle Island (1080 ha, 235 species of plants), but many are small and poorly vegetated and many islets have no known plant species being no more than exposed rocks. Most of the Archipelago was classified as an A class reserve in April 1980.

European discovery of the archipelago commenced in 1627 when Nuijts sailed through seas to the south of the archipelago. The next visit was by Vancouver in 1791 who proposed the first name for one of the islands, the southernmost, Termination Island. However the Archipelago remained relatively unexplored, certainly, by naturalists, until the visit by Flinders in 1802. Smith and Johnstone (1996) outlined the history of subsequent explorations in the Archipelago by naturalists.

The Eastern Group of the Archipelago of the Recherche consists of ten named islands, three named rocks (Figure 1) and numerous unnamed islets and rocks. It is the most easterly group of islands in the Archipelago and the least known scientifically because of its remoteness. The nearest islands in an easterly direction are in the Nuyts Archipelago off Ceduna, South Australia, 1000 km to the ENE making the islands of the Eastern Group of the Archipelago the easternmost seabird-breeding islands off the south coast of Western Australia.

Since 1947 various islands of the Eastern Group have been visited by a number of naturalists including D.L. Serventy in 1947 and 1948, V.N. Serventy and J.R. Willis in 1950 (see Serventy 1952, 1953; Willis 1953). Since then personnel from the Department of Fisheries and Wildlife and, more recently, from the Department of Conservation and Land Management have visited parts of the Eastern Group, but few data have been published from these visits.

In the mid 1980's the Western Australian Museum began accumulating data on the Eucla Division of Western Australia in preparation for a publication on the birds of that area (Storr 1987). Part of that program was to visit as many islands as possible, particularly small islands which are often important for seabirds. For example Six Mile Island is only 10 ha in area, has only five species of plant but is a breeding site for six species of seabird (Johnstone and Smith 1987).

METHODS

Two of the current authors made the following visits to the Eastern Group in the 1980's: Johnstone visited Six Mile Island in January 1985; Smith and Johnstone visited Six Mile Island on 30 October 1985 and 23 February 1986, Daw and New Year Islands on 19 February 1986 and Anvil Island on 23 February and 17 April 1986. They also made observations from the sea at Ford Island on 19 February 1986 and on Pointer Island on 17 April 1986.

In May 1991 the Australian Geographical Society organized a major expedition to the Archipelago including islands in the eastern Group that had not previously been visited by naturalists. Dell and herpetologist Brad Maryan were members of this expedition. They were accompanied by botanist Greg Keighery who described the vegetation and listed the floristics of each island visited (Keighery 1995). Dell and Maryan visited Daw and New Year Islands on 5-7 May 1991 and Spindle, Anvil and Six Mile Island on 7 May 1991.

The following annotated lists of the terrestrial vertebrates of the Eastern Group includes previously published data, Western Australian Museum records (mammals and reptiles)

and data collated during our visits.

DESCRIPTION OF ISLANDS

Anvil Island (33°44'S, 124°05'E, area 25 ha, 20 m high). Two low granite hills are separated by a vegetated valley with a beach on each side. The three low heath and herbfield vegetation associations were described by Keighery (1995) who listed 27 plant species recorded for the island.

Daw Island (33°51'S, 124°04'E, 2.7 km long, 180 ha, 141 m high) has a granite base with a low limestone saddle at the central isthmus which narrows to about 100 m. Exposed granite on the east side and each end slopes steeply into the sea. The western side has a sandy beach backed by *Spinifex hirsutus* and *Nitraria billardierei* and, towards the southern end, there is a low limestone cliff. Protected lowlands are covered with low, dense scrub dominated by *Paraserianthes lophantha* and *Atriplex* which is tallest (up to 2 m) and densest at the base of the northern peak. More exposed areas are carpeted with *Carpobrotus* and *Sporobolus virginicus*. Willis (1954) recorded 46 species of plant for the island (but not *Melaleuca lanceolata*). We also made a small plant collection which included a

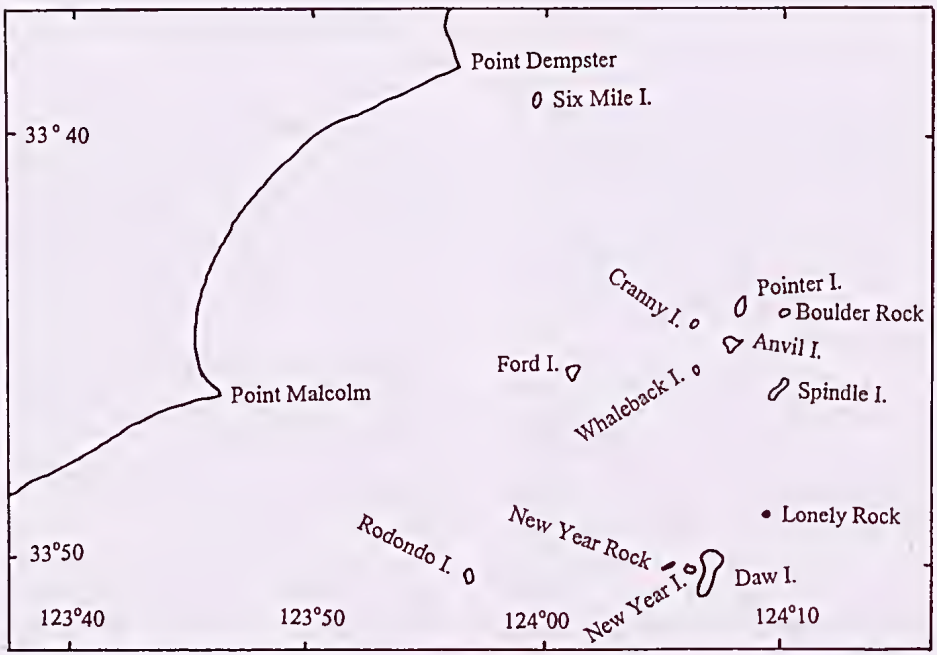

Figure 1. Positions and names of Islands in the Eastern Group, Archipelago of the Recherche.

specimen of *Melaleuca lanceolata* taken from a small, tall, dense stand in the middle of the island. We also found a freshwater seepage at the foot of the northern (tallest) peak. Fairbridge and Serventy (1954, p. 14) show a photograph of the island.

Ford Island (33°46'S, 124°02'E, area 15 ha, 0.6 km long, 27 m high). Smith and Johnstone passed within 200 m of this island en route to Daw Island in February. It is similar to Pointer Island but domed, has extensive areas of bare granite, and little vegetation (mostly *Carpobrotus*). From that distance the soil build-up on Pointer and Ford Islands did not appear deep enough to support breeding colonies of burrowing petrels.

New Year Island (33°51'S, 124°07'E, area 12 ha, 0. 7 km long, 32 m high). About two thirds is mostly exposed granite and the tallest vegetation is less than 50 cm tall. Keighery (1995) described the three main vegetation types and listed 23 plant species recorded. There is a small area of limestone on the southeast end (opposite Daw Island) that provides the only topsoil deep enough for burrowing seabirds. It is also the tallest vegetated area with thickets of *Nitraria billardierei* over *Threlkedia diffusa* (Keighery 1995).

Pointer Island (33°43'S, 124°05'E, area 20 ha, 1 km long, 29 m high). Smith and Johnstone made an unsuccessful attempt to land on this island which is mostly bare granite. It has very steep sides and is topped with a sloping plateau. The vegetation appears to be almost exclusively *Carpobrotus virescens*.

Six Mile Island (33°38'S, 123°59'E) is a granite rock with five plant species (Keighery 1995). Incorrectly called Six Mile Rock by Keighery (1995).

Spindle Island (33°46'S, 124°10'E) is mostly bare granite and has only four plant species (Keighery 1995).

Other islands in the Eastern Group (Rodondo (incorrectly called Rodona on some maps), Whaleback and Cranny Islands) apparently have not been visited by naturalists.

RESULTS

BIRDS

Pacific Black Duck *Anas superciliosa*

Six Mile Island – ten in January 1985. Mr L. Spurr of Israelite Bay informed R.E. Johnstone in 1985 that Black Ducks visit other islands in the Eastern Group.

Grey Teal *Anas gracilis*

Six Mile Island – eleven in May 1991.

Cape Barren Goose *Cereopsis novaehollandiae grisea*

Anvil Island – nine in February 1986, five in April 1986, and nine live and four dead in May 1991.

Daw Island – fifteen on *Carpobrotus*-covered slopes in February 1986, six live and ten dead birds in May 1991. Serventy

(1952) counted 12 in November.

New Year Island – one live and four dead in May 1991.

Six Mile Island - five in May 1991.

The large number of dead birds on these, as well as other islands examined in May 1991 was probably the result of starvation due to the prolonged drought which had markedly affected the vegetation of many islands at the time. In some places whole plant associations were dead and others were markedly stressed and close to death. Vegetative growth would have been severely reduced for several months and may have resulted in starvation in many geese. About 40% of geese recorded throughout the archipelago in May were dead birds.

Little Penguin *Eudyptula minor novaehollandiae*

Anvil Island – two feathered chicks under *Nitraria billardierei* in February 1986, about 12 burrows under *Nitraria*, several empty burrows under *Disphyma clavellatum* in May 1991.

Six Mile Island – nesting all over the island on 25 January 1985 but most nests at the southern end where the granite is more jumbled. All nests examined contained adults or chicks. Chicks ranged from half grown downy young to fully feathered young. Young often sitting in crevices together (groups up to eight). Thirty-three young counted. Forty-five adults under slabs of granite in October 1985. There were 22 empty nests, one nest with two eggs, one nest with a dead chick and a chipped egg, one nest with two almost fully fledged young, and one nest with two newly hatched black chicks with white bellies. None recorded in February 1986. Two adults under rock in May 1991.

Daw Island - there were 300-500 burrows scattered among the Fleshy-footed Shearwater burrows in February 1986. Two moulting adults were under granite slabs among *Paraserianthes lophantha* and *Carpobrotus* and a downy chick was in one nest. At least 30 burrows under low shrubs were occupied by adults in May 1991. Recorded from Daw I. in Serventy and Whittell (1951).

New Year Island – we found a few feathers at the mouth of a deep burrow in February.

Yellow-nosed Albatross *Diomedea chlororhynchos*

One at sea between Anvil I. and Point Dempster in April 1986, one at sea between Daw and Spindle Is, one between Spindle and Anvil Is, and one between Six Mile I. and Point Malcolm in May 1991. More abundant in seas to west of Point Malcolm in May and in June and July (Serventy 1952).

Black-browed Albatross *Diomedea melanophris*

One at sea between Daw and Spindle Is, one between Spindle and Anvil Is, and two between Six Mile Island and Point Malcolm in May 1991. More

abundant in seas to west of Point Malcolm in May 1991.

Shy Albatross *Diomedea cauta*
D.L. Serventy saw one off Daw I. in July 1947 (Serventy 1952).

Cape Petrel *Daption capense*
One dead on Six Mile Island in January 1985. Two over seas between Six Mile Island and Cape Pasley in May.

Great-winged Petrel *Pterodroma macroptera*
Several near Daw I. in February 1986.

Fleshy-footed Shearwater *Puffinis carneipes*
Anvil Island – a few empty burrows when a skeleton was collected in May 1991.

Daw Island – Serventy (1952) recorded only a few burrows in November 1950 but in February 1986 we estimated that there were 5,000-10,000 breeding pairs present mainly in sandy areas. All 12 burrows examined contained an adult brooding a chick. In May two colonies of hundreds of burrows were located. About 10% of the first burrows had a large chick with some down on lower abdomen and head and fresh adult tracks after rain. The second colony had abandoned burrows. About 12 adults were seen leaving the island at 0600 hrs on 6 May 1991.

This species begins renovating burrows from the end of September to the beginning of November and egg laying begins in late November to mid December. We doubt that Serventy would have overlooked such a large colony so it would appear that the species has greatly increased since the 1950's.

Little Shearwater *Puffinis assimilis*
Anvil Island – we found 700-800 of their burrows, mostly under *Carpobrotus* and *Atriplex* on the eastern side of the island in February 1986. Six burrows excavated were empty but one adult was heard calling from a burrow. On our return in April 1986 many of the burrows were freshly excavated but unoccupied. A few burrows were freshly excavated in May 1991 and a skeleton was collected.

Daw Island – two skulls were collected in the *Melaleuea lanceolata* thicket in February 1986.

New Year Island – a few *P. assimilis*-sized burrows in shallow soil on limestone in February 1986.

White-faced Storm Petrel *Oceanites marinus*
Anvil Island – we found 200-300 burrows in groups of 30-100 in February 1986. One of the five burrows examined contained a feathered juvenile with down on its neck and around the vent.

Daw Island – Serventy (1952) reported many burrows in November 1950 but we found no sign of their burrows in February 1986 or May 1991, although we did not search the whole island.

New Year Island – five empty burrows in May 1991 were probably this species.

Australasian Gannet *Sula serrator*
Four adults were seen between Point Dempster and Daw I. in February 1986 and 19 adults and two immatures between Point Dempster and Anvil I. in April 1986. Seventeen adults and one immature were seen en route to Anvil I. in April 1986 and 14 adults and 2 immatures were seen on our return from Anvil I. to Point Dempster the same day. One was seen near Anvil I. and four near Six Mile I. in May 1991. Much more abundant in seas to west in May 1991.

Black-faced Cormorant *Phalacrocorax fuscescens*
Six Mile Island – twenty on small rock at eastern end of island in October 1985. One seen en route from Israelite Bay to Anvil I. in April 1986.

White-faced Heron *Ardea novaehollandiae*
Daw Island – D.L. Serventy saw one in a pool on granite in July 1947 (Serventy 1952).

Eastern Reef Heron *Ardea sacra*
Spindle Island – one in May 1991.

White-breasted Sea Eagle *Haliaeetus leucogaster*
Anvil Island – two adults and a brownish juvenile at a nest in February 1986.

Daw Island – two pairs in May 1991. Feeding platforms contained skeletons of three leather jacket fish. V.N. Serventy (Serventy 1952) found an old nest on the northern peak. Another nest half way up the peak contained a large young bird.

Pointer Island – one adult in February 1986.

Six Mile Island – previously known to nest (L. Spurr *pers. comm.*).

Australian Kestrel *Falco cenchroides*
Daw Island – one in February and two in May 1991. V.N. Serventy saw one in November 1950 (Serventy 1952).

Buff-banded Rail *Gallirallus phillippensis*
Anvil Island – one in *Nitraria billardierei* thicket and a dead bird nearby in May 1991. An orange-legged rail about 25 cm tall at the edge of a *Nitraria* thicket in February (L. Spurr *pers. comm.*) was probably this species.

Daw Island – two in a 2m tall *Paraserianthes lophantha* thicket at the base of the granite hill at the eastern end of the island in February 1986. V.N. Serventy (Serventy (1952) recorded one in November 1950.

Spotless Crake *Porzana tabuensis*
Anvil Island – one in *Nitraria billardierei* thicket in May 1991.

Daw Island – three (one of them collected) in February 1986, three in *Paraserianthes lophantha* thickets in May 1991.

Brown Quail *Coturnix ypsilophora*
Daw Island – birds attributed to this species were seen by V.N. Serventy (Serventy 1952).

Grey-tailed Tattler *Tringa brevipes*
Six Mile Island – one with Ruddy Turnstones in February 1986.

Ruddy Turnstone *Arenaria interpres*
Six Mile Island – one in October 1985, 35 in February 1986 and four in May 1991.

Spindle Island – fifteen in May 1991.

Common Sandpiper *Tringa hypoleucos*
Six Mile Island – two in January 1985.

Little Stint *Calidris minuta*
Six Mile Island – 12 with Grey-tailed Tattler and Ruddy Turnstones in February 1986.

Sooty Oystercatcher *Haematopus fuliginosus*
Anvil Island – two in February 1986 and April 1986, three on rocks in May 1991.

Daw Island – six in February and six in May. V.N. Serventy saw two in November 1950 (Serventy 1952).

New Year Island – two in May 1991.

Six Mile Island – seven in January 1985, thirteen in October 1985, seven in February 1986, eight in May 1991. All were at the splash zone on granite.

Spindle Island – two in May 1991.

Grey Plover *Pluvialis squatarola*
Anvil Island – three in May 1991.

Red-necked Stint *Calidris rufficollis*
Anvil Island – five in May 1991.

Six Mile Island – one in January 1985, one in October 1985 and 30 in May 1991. A specimen collected on 23 February 1986 (CSIRO band 032-49361) was banded at Pelican Point, Swan River, Perth on 15 December 1984 by the Western Australian Wader Study Group.

Red-capped Plover *Charadrius ruficapillus*
Anvil Island – one in February 1986, 15 on rocks in May 1991.

New Year Island – one in May 1991.

Six Mile Island – four in May 1991.

Greater Sand Plover *Charadrius leschenaultii*
Six Mile Island – eight in October 1985.

Hooded Plover *Charadrius rubricollis*
Six Mile Island – two in January 1985, one collected in February 1986.

Brown Skua *Catharacta antarctica lonnbergi*
Six Mile Island – three over seas close to island in May 1991.

Arctic Skua *Stercorarius parasiticus*
Daw Island – D.L. Serventy saw one off island on 16 July 1947 (Serventy 1952).

Six Mile Island – three over seas close to island and three further out in May 1991.

Silver Gull *Larus novaehollandiae*

Anvil Island – nineteen in February 1986, six in May 1991.

Daw Island – 15 recorded in February 1986 including 3 immature birds, a total of 14 in May 1991. One in November 1950 (Serventy 1952).

New Year Island – one in May 1991.

Six Mile Island – about 50 adults on island in October 1985. There were two separate breeding groups among low vegetation between jointing planes in granite. The colony near the centre of the island had four nests comprising one with 3 eggs, two with 2 eggs, and one with a downy chick. There were also eight dead chicks and 13 runner chicks with buff edges to feathers and down on head. Ten adults in May 1991.

Spindle Island - six in May 1991.

Pacific Gull *Larus pacificus*

Anvil Island – an immature in February and three in May 1991

Daw Island – four adults and five immature birds in February 1986, a total of 32 seen in May 1991. V.N. Serventy found two nests on Daw 1, one with two eggs (chicks heard cheeping) and the other with one egg (Serventy 1952).

New Year Island – one in May 1991.

Six Mile Island – two adults in October and two adults in February 1986.

Spindle Island – three in May 1991.

Caspian Tern *Sterna caspia*

Anvil Island – two in February 1986.

Daw Island – one seen in November 1950 (Serventy 1952).

Six Mile Island – Five in January 1985, two pairs each with 2 eggs in October 1985. Nests were in small depressions in granite.

Crested Tern *Sterna bergii*

Anvil Island – one in February 1986 and two in May 1991.

Daw Island – 21 in seas close to island in May 1991. V.N. Serventy saw a flock of 200-300 in November 1950 (Serventy 1952).

New Year Island – two in February 1986.

Ford Island – two in February 1986.

Six Mile Island – fifty in January 1985, 140 in October 1985. About 1000 breeding pairs in February 1986. Chicks ranged from newly hatched up to black-capped speckled birds almost ready to fly. L. Spurr (*pers comm.*) told Johnstone and Smith that adults were incubating on 8 January. The breeding site of these Crested Terns was mapped by Johnstone and Smith (1987) but the relevant details were inadvertently omitted from the text.

A total of 14 were seen while travelling between Six Mile Island and Point Malcolm in May 1991.

Spindle Island – one in May 1991.

Fairy Tern *Sterna nereis*

Six Mile Island – about 45

breeding pairs in two areas of *Carpobrotus* on 25 January 1985. Four nests had one egg, seven had two and nine fresh empty scrapes were counted. Two adults were flying above and around the island on 30 October 1985. Eight adults and one young still begging for food in February 1986.

Several birds seen between Six Mile Island and Point Malcolm on 7 May need confirmation as Storr (1987) considers that birds in winter could be migrating Little Terns *Sterna sinensis*.

Rock Parrot *Neophema petrophila*

Anvil Island – twenty-eight, mostly in pairs sheltering under granite boulders in January 1985, six in *Nitraria* in February 1986, six feeding on *Enchylaena* and three feeding on male flowers of *Atriplex cinerea* and *Olearia axillaris* flower buds in May 1991.

Daw Island – three perched on rocks among *Carpobrotus* in February 1986, a total of 34 in May 1991. V.N. Serventy saw five in November 1950 (Serventy 1952).

New Year Island – ten feeding on *Calocephalus brownii* in May 1991. D.L. Serventy saw 100 in June 1948 (Serventy 1952).

Six Mile Island – two in October 1985, 44 in February 1986 and two in May 1991.

Barn Owl *Tyto alba*

Daw Island – one flushed from a granite ledge at the east end of island in February 1986. Pellets around the rock contained the remains of *Rattus fuscipes*. Pellets, presumably from this species, in cavern on northern peak in May 1991 also contained bones of two *Rattus fuscipes*.

Welcome Swallow *Hirundo neoxena*

Anvil Island – four in April 1986, six feeding over island in May 1991.

Daw Island – 10–15 in February 1986, 18 feeding over island and 40 sheltering among rocks in May 1991. V.N. Serventy (Serventy 1952) recorded Welcome Swallows in November 1950.

New Year Island – two feeding above splashing waves in May 1991.

Six Mile Island – two in January 1985, three in October 1985 and nine feeding over island in May 1991.

Red Wattlebird *Anthochaera carunculata*

Anvil Island – one among rocks in May 1991.

Grey-breasted White-eye *Zosterops lateralis*

Anvil Island – heard in *Nitraria* in February, 14 feeding on *Nitraria* berries and two feeding among *Disphyma* in May 1991.

Daw Island – several groups in dense scrub in February, a total of eight in *Nitraria* and four in *Paraserianthes lophantha* in May 1991. Recorded by V. N. Serventy (Serventy 1952).

New Year Island – 20 in *Rhagodia* in May 1991.

Australian Raven *Corvus coronoides*
Daw Island – six in May 1991 and six in November 1950 (Serventy 1952).

Australian Pipit *Anthus australis*
Anvil Island – two among 15 cm tall *Atriplex cinerea* and two among *Disphyma* in May 1991.

Daw Island – 10–20 mostly on *Carpobrotus* in February 1986, five among *Disphyma* and on rocks in splash zone in May 1991. V.N. Serventy saw three in November 1950 (Serventy 1952).

New Year Island – five in May 1991.

MAMMALS

Southern Brown Bandicoot *Isoodon obesulus*
Daw Island – There are five specimens in the Western Australian Museum from Daw Island (M4011, 3229-30, 22305, 25556). We saw several animals and collected M25556 in February 1986. At least five animals were active during the daytime in May 1991. We gained the impression that this species was quite common. Several of their disused grass nests were found in both February 1986 and May 1991.

Bush Rat *Rattus fuscipes*
Daw Island – one specimen in the Western Australian Museum (M24595). The Death Adder collected in February 1986 had one in its gut. Several skulls were collected from pellets of Barn Owls in May 1991.

Australian Sea-lion *Neophoca cinerea*
Anvil Island – three males with bright mantles, one male without a mantle, 20 females and several yearlings in February 1986. At least 10 animals in May 1991.

Daw Island – V.N. Serventy (Serventy 1952) counted 65 on the beach in November 1950. Smith and Johnstone saw 20 on the same beach in February 1986.

Ford Island – two in February 1986.

New Year Island – four in May 1991.

Six Mile Island – 26 adults (including 6 males and 20 females) 12 juveniles and one pup in October, at least 15 animals in May.

Spindle Island – 119 in May 1991.

New Zealand Fur-seal *Arctocephalus forsteri*
Anvil Island – breeding colony present in May 1991.

Daw Island – one in February 1986. In May a colony of about 50, of which about half were pups, occupied the rocks in the channel between Daw and New Year islands. Another colony of 26 was at the northern end of the island.

REPTILES

Specimens collected are in the

Western Australian Museum. For a summary of the reptiles of the entire Archipelago of the Recherche see Smith and Johnstone (1996).

Gekkonidae (Geckos)

Marbled Gecko *Christinus marmoratus*
Daw Island – five under granite slabs in May 1991. One collected on Daw I. by Department of Fisheries and Wildlife personnel April 1982. Two collected by A.J. Hopkins in June 1988.

Barking Gecko *Underwoodisaurus milii*
Anvil Island – One sloughed skin found under granite in February 1986.

Daw Island – two under granite in May 1991.

New Year Island – adult collected from under granite photographed in May 1991. Not previously recorded for New Year Island.

Agamidae (Dragon Lizards)

Rock Dragon *Ctenophorus ornatus*
Daw Island – common on granite. Also recorded here previously (Glauert 1954).

Scincidae (Skinks)

Red-legged Skink *Ctenotus labillardieri*
Anvil Island – several seen under granite in February 1986, April 1986 and May 1991.

South-western Crevice Skink *Egernia napoleonis*
Daw Island – common under granite in May 1991, also seen in February 1986.

New Year Island – common under granite in May 1990, also seen in February 1986.

Anvil Island – common among granite in February 1986, April 1986 and May 1991.

Six Mile Island – the only lizard on the island, abundant.

Egernia multiscutata bos
Anvil Island – One dug from a Little Shearwater burrow in February 1986 and one seen in burrow in May 1991.

Hemiergis peronii
Anvil Island – Three in loose soil under granite.

Menetia greyii
Daw Island – two individuals, possibly this species, seen in May 1991 by Dell.

New Year Island – one individual, possibly this species, seen in February 1986 by Smith.

If these observations are confirmed they would be the first records of this species on any islands of the Recherche Archipelago (Smith and Johnstone 1996).

Elapidae (Front-fanged snakes)

Death Adder *Acanthophis antarcticus*
Daw Island – several seen in February 1986, two seen in May 1991. The one specimen collected in February had a *Rattus fuscipes* in its gut.

Crowned Snake *Elapognathus coronatus*
Daw Island – One collected by Fisheries and Wildlife personnel April 1982. One basking on granite in May 1991. Also recorded previously (Glauert 1954).

DISCUSSION

The 45 species of birds recorded from the Eastern Group of the Archipelago of the Recherche can be divided into two groups; those dependent on a marine or littoral environment and land birds which occur on the nearby mainland and visit, or have become resident on the Archipelago's islands. The former group (74 % of the avifauna) can be divided into four categories as listed below.

The first of these categories comprises certain pelagic or oceanic petrels and shearwaters which visit or breed in this, or other parts, of the Archipelago. Breeding species include the Great-winged Petrel *(Pterodroma macroptera)*, Fleshy-footed Shearwater *(Puffinis carneipes)*, Short-tailed Shearwater (*Puffinus tenuirostris)*, Little Shearwater (*Puffinus assimilis)*, and White-faced Storm Petrel *(Oceanites marinus)*.

The Cape Petrel *(Daption capense)* is a non-breeding visitor.

The second category includes the following subantarctic and arctic visitors: Black-browed Albatross *(Diomedea melanophris)*, Yellow-nosed Albatross *(D. chlororhynchos)*, Shy Albatross (*D. cauta)*, Wilson's Storm Petrel *(Oceanites oceanicus)*, Arctic Skua *(Stercorarius parasiticus)*, and Brown Skua (*Catharacta antarctica)* and Australasian Gannet *(Sula serrator)*.

The third category comprises the following Palaearctic migrants: Grey-tailed Tattler (*Tringa brevipes*), Ruddy Turnstone *(Arenaria interpres)*, Common Sandpiper (*Tringa hypoleucos*), Little Stint (*Calidris minuta*), Grey Plover *(Pluvialis squatarola)*, Red-necked Stint *(Calidris ruficollis)* and Greater Sand Plover *(Charadrius leschenaultii)*.

The fourth category includes the following resident laro-limnocolae, shags, raptors, ducks, and penguins, most of which are dependent on the sea for food and the land for breeding (those asterisked breed in the Eastern Group of the Archipelago): Little Penguin *(Eudyptula minor)**, Black-faced Cormorant *(Phalacrocorax fuscescens)**, White-faced Heron *(Ardea novaehollandiae)*, Eastern Reef Heron *(Ardea sacra)*, Pacific Black Duck *(Anas supercilosa)*, Grey Teal *(A. gracilis)*, Sooty Oystercatcher *(Haematopus fuliginosus)**, Red-capped Plover *(Charadrius ruficapillus)*, Silver Gull *(Larus novaehollandiae)**, Pacific Gull *(L. pacificus)**, Caspian Tern *(Sterna caspia)**, Crested Tern (*S. bergii)**, Fairy Tern (*S. nereis)**, and White-breasted Sea Eagle *(Haliaeetus leucogaster)**.

The second group, the land birds,

are very poorly represented with only 12 species being recorded. Of these only the Cape Barren Goose *(Cereopsis novaehollandiae grisea)* has been found breeding on the islands, although it is most likely that the Rock Parrot *(Neophema petrophila)*, Barn Owl *(Tyto alba)*, Welcome Swallow *(Hirundo neoxena)*, Australian Pipit *(Anthus australis)*, and Grey breasted White-eye *(Zosterops lateralis)* breed here also. The Kestrel *(Falco cenchroides)*, Buff banded Rail *(Gallirallus phillippensis)*, and Spotless Crake *(Porzana tabuensis)* possibly breed here. It is unlikely that the Red Wattlebird *(Anthochaera carunculata)* or the Australian Raven *(Corvus coronoides)* breed here. The current status of the Brown Quail *(Coturnix ypsilophora)* on Daw Island remains uncertain.

The subspecies of the Cape Barren Goose *(Cereopsis novaehollandiae grisea)* is the only bird endemic to the Archipelago of the Recherche. As a result of data obtained in May 1991 this subspecies was subsequently included in Schedule 1 of the Wildlife Conservation Act as "Fauna Which is Rare or Likely to Become Extinct".

Of the 45 species of bird recorded from the Eastern Group, only two, the Buff-banded Rail *(Gallirallus philippensis* and Spotless Crake *(Porzana tabuensis)* appear restricted to the eastern end (but not necessarily the Eastern Group) of the Archipelago, the Buff-banded Rail being only recorded from Daw and Anvil Islands in the Eastern Group and the Spotless Crake from Daw as well as inshore islands (Wickham, Skink, Ben, and Bellinger) further west.

The Southern Brown Bandicoot *(Isoodon obesulus)* from Daw I. represents only the second insular population off the Western Australian coast. The only other island population being on Bald Island near Albany. Accordingly the Daw Island population is important in a conservation context as the species has declined over much of its range on the mainland.

Ten species of reptile are now known from the islands of the Eastern Group compared to the total of 21 species from the whole archipelago. This low number of species is not surprising considering the small size of most of these eastern islands and the fact that little vegetation and soil is present on most (Keighery 1995). The most abundant populations of some species are practically restricted to the crevices in the exposed granite.

Nine of the species of reptile from the Eastern Group are found in other parts of the Archipelago (Smith and Johnstone 1996) and most are common on the opposite mainland. The only exception is *Menetia greyii* on Daw and New Year Islands, the records of which require confirmation.

ACKNOWLEDGEMENTS

We are grateful to Mr L. Spurr of

Israelite Bay for his hospitality and for taking Smith and Johnstone to islands in the Eastern Group and to Mr N. Kolichis and Mr and Mrs W.H. Butler whose grants to the Western Australian Museum helped defray the costs of the field work by Smith and Johnstone. Australian Geographic organised the May trip and covered all costs some of which were sponsored by BP Australia. The McKenzie family of Esperance provided the boat and crew for the May expedition. Brad Maryan is thanked for access to his reptile data and Nick Gales for his data on marine mammals from the May trip.

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Praying Mantis preying on Vertebrates – An observation of a praying mantis killing and partially eating a Brown Honeyeater (*Lichmera indistinca*) at the tourist resort of El Questro Station, off the Gibb River Road in the East Kimberley region of Western Australia is reported. Three other records of praying mantises eating vertebrates in Western Australia are also included.

While acting as a tour guide with Coate's Wildlife Tours, and camped at El Questro Station, a Brown Honeyeater was observed being caught, killed and partially eaten by a praying mantis, which was green in colour and 80 to 100mm in length. Photos were taken and sent to the Western Australian Museum, however identification of the species has not been possible. These types of incidents have been rarely recorded in the past. The following observations were made on the 17 July 2003 from approximately 12.30pm to 2.00pm.

Whilst observing two Brown Honeyeaters feeding in a flowering *Grevillea agrifolia*, two members of the tour group, Brenda and Graeme Smith, saw a large green praying mantis, which was waiting motionless in the foliage suddenly seize one of the honeyeaters. The mantis caught the honeyeater by its head in its right foreleg and appeared to be injecting the other foreleg into the bird. Initially the victim beat its wings frantically in an endeavour to escape. Almost immediately two or three other Brown Honeyeaters, one thought to be its mate, attacked the praying mantis. It was at this stage I was called to the scene from nearby and alerted to what was happening.

The mantis, unaffected by the attacks by the other honeyeaters held on to its prey very securely. About one minute after capture, the trapped honeyeater ceased to struggle and hung lifelessly in the mantis' grasp. It appeared to be dead. The praying mantis then proceeded to remove all feathers from the throat of the honeyeater with its mouth and began to eat the flesh. After about one hour from the initial capture, I left the scene, but returned at 10-minute intervals to observe and note the situation. At one stage it appeared to be sucking the contents from the head. The position of both the honeyeater and the mantis did not change at all during this time, with the mantis continuing to hold on to the honeyeater with its forelegs as it fed. Attacks by the other honeyeaters decreased as time progressed. However, one bird, presumed to be the victim's mate continued to fly around in an agitated state and remained in the same tree during the entire episode.

Approximately one and a half

hours after capture the remains of the honeyeater were found lying at the base of the tree. The head and neck had been severed from the body and on close examination all the flesh including the eyes, but not the tongue, had been removed. I noted that the contents of the skull had also been completely removed. The body did not appear to have been touched, and the backbone, bare of flesh, was protruding from the top of the body.

Unfortunately, I did not keep the dead bird for further investigation. After searching for several minutes, the mantis was located in almost the same position, blending so well with the leaves that it was almost impossible to see it amongst the foliage.

Through discussion with others I have become aware of two other unpublished incidents where praying mantises have caught and eaten (or attempted to eat) vertebrates. At Dampier in the Pilbara in about 1990, Tom Moore of Busselton recollected seeing a praying mantis eating an unidentified freshly captured frog. In 1999, at "Kingston Rest" in the East Kimberley, Caroline Garstone investigated 'dreadful screams coming from a frog in their garden' and discovered a praying mantis in a tree that had captured a Green Tree Frog (*Litoria caerulea*). The praying mantis, which was holding the frog with its forelegs, was eating it while it was still alive.

Another incident occurred about 10.30am in June 2001. Jan Lewis, Helen McArthur and Johnny Schoenjahn released a Red-backed Fairy-wren (*Malurus melanocephalus*) weighing 6.7gms caught that day from their banding station in the mangroves at the mouth of Willie Creek north of Broome. The bird went off without any hesitation. However they were alerted a minute or two later by the sound of a number of wrens calling when previously none had been sighted or heard. There were at least eight Red-backed and Variegated Fairy-Wrens (*M. lamberti*) hopping through the mangroves in great excitement and for a moment or two their attention focused on them. They then realised the released bird was in trouble. It was hanging from its neck, fluttering its wings and appeared to be caught in a twig. To their amazement, on close inspection, the twig proved to be a large praying mantis, which had the wren in its front legs. Both the wren and the praying mantis were then captured. The praying mantis weighed 7.5gms and was almost 10 cms long (98mm from head to tail). Both the wren and the praying mantis were then released. The wren appeared to have sustained some damage to one eye but flew off strongly and was re-trapped a year later, still in good condition, with no apparent damage to the eye.

The literature refers to praying mantises having previously been

recorded eating vertebrates in Australia. In one reference by David Rence (1996) on p.242 in *Grasshopper Country, the Abundant Orthopteroid Insects of Australia* (p.242), the mantis involved belonged to the genus *Hierodula*, a genus "containing a large, robust species that have been known to feed on small vertebrates". Balderson (1991) in Chapter 21 (p.351) in *The Insects of Australia* refers to some larger species of mantises that have been recorded feeding on frogs, small lizards and fledgling birds.

I would like to thank Brenda and Graeme Smith for their help in recalling events and Wynton Maddeford for his help in locating other relevant information including the Red-backed Fairy-wren article. Also thanks to Jan Lewis, Helen McArthur, and Johnny Schoenjahn for allowing me to quote from their article. Special thanks to Kevin and Yvonne Coate for their help and encouragement to prepare this article and to John Dell for editing it for publication.

– STEVE DALE, P.O. Box 2235, Broome, WA, 6725.

Observations of a Dibbler (*Parantechinus apicalis*) feeding on *Banksia media* - The Fitzgerald River National Park, on the south coast of Western Australia, is home to the only known natural population of the Dibbler (*Parantechinus apicalis*) on the mainland (Start, T., 1998, Dibblers. *Landscope* 14 (2): 28-34). Commencing in 2001, as part of the Dibbler Recovery Program, another population was established at Peniup proposed nature reserve, approximately 25 kilometres west of the Fitzgerald River NP (Friend, J.A., 2004, Dibbler (*Parantechinus apicalis*) Recovery Plan, July 2003 – June 2012. CALM, Perth).

While trapping to monitor the reintroduced Dibbler population at Peniup, we observed a *P. apicalis* eating from the flower of a *Banksia media*. On the morning of 18 March 2004, we were checking a grid of Elliott traps. It was quite a pleasant morning with sunshine, clear skies and a slight breeze.

At approximately 8:05 am we found a male *P. apicalis*, ninety grams in weight, in one of our traps. We had caught this individual two days earlier. He had patches of lost fur and had lost the tip of his tail prior to the first capture. Upon release, the Dibbler moved quickly into the shelter of nearby bushes. Soon afterwards, a Dibbler (presumably the same individual) returned from the direction in which it had left. The animal moved to the bottom of the nearest *Banksia media* bush, roughly four metres from us, and began to climb up onto the lower branches. We watched as the *P. apicalis* moved across to a large flower about 400mm off the ground, 110mm in height and 75mm in diameter.

The *P. apicalis* climbed completely onto the flower so that its body no longer touched the branches. It circled around the flower before pushing its nose into the centre for two or three seconds. The *P. apicalis* moved around the flower quite rapidly, lingering at one spot for a few seconds before moving to a different part of the flower. This continued for around 2 to 3 minutes before the *P. apicalis* had either finished or was disturbed. It then climbed back on to the banksia branches and started heading towards us, staying on the banksia. When it got to within 3 metres of us, it looked in our direction and turned around. It jumped onto the ground and ran across a clearing towards another banksia, with the tip of his tail raised to approximately 40° to the horizontal. By this time it was about 8.25 am. The whole observation had been in broad daylight.

Once the *P. apicalis* was out of sight, we examined the banksia flower that it had eaten from. We found no insects present and nectar could not be felt on the fingers. However, upon inspection of a different flower of the same species, both small insects and nectar were present.

Dibblers were thought to be extinct until they were rediscovered in January 1967 by wildlife photographer Michael Morcombe. He placed flywire traps over the flowers of *Banksia attenuata* at Cheyne Beach, to catch Honey Possums (*Tarsipes rostratus*) as they fed on the flowers. By the second morning, he had rediscovered the Dibbler (Morcombe, M., 1967, The rediscovery after 83 years of the Dibbler *Antechinus apicalis* (Marsupialia, Dasyuridae), *The Western Australian Naturalist*, 10: 108-109).

We would like to thank Dr. Tony Friend for providing guidance in writing this article.

– RENÉE-CLAIRE HARTLEY and SAUL COWEN, CALM, 120 Albany Highway, Albany WA 6330.

A Record of the Flower-Pot Blind Snake *Ramphotyphlops braminus* from a Perth Suburb - The Flower-pot Blind Snake (*Ramphotyphlops braminus*) is an endemic species to South East Asia (Wilson and Swan 2003, *A Complete Guide to Reptiles of Australia*. Reed New Holland Publishers Australia, Sydney). The species has been introduced all over the world (Shine1998, *Australian Snakes A Natural History*. Reed New Holland Publishers Australia, Sydney) including Indo-pacific region, Eurasia, Africa, Madagascar, Mauritius, Indo- Malayan region, New Guinea, Hawaiian Islands, Mexico, Iran and Australia (Storr, Smith and Johnstone 2002, *Snakes of Western Australia*. Revised Edition. Western Australian Museum). Within Australia the species has slowly been introduced throughout the tropical and arid regions being recorded in Torres Strait Islands, Darwin, Kununurra, Dunham River Station, Karratha, Port Hedland and Townsville (Wilson and Swan 2003; Storr, Smith and Johnstone 2002; Maryan 2001, The House Gecko *Hemidactylus frenatus* and Flower-Pot Blind Snake *Ramphotyphops braminus* in Western Australia. *Herpetofauna* 31 (1): 26–27).

On 19 February 2004 a juvenile blind snake was handed into Perth Zoo by a member of the public. It was taken to the Western Australian Museum and identified as *R. braminus*, number R154547 (Brad Maryan per comm.). The snake is very small measuring 0.2grams, SVL: 66mm, TL: 2mm and purple/brown in colour.

The snake was found on the living room floor of a suburban home in Hamilton Street, Kewdale, Perth. The family had recently purchased some pot plants from the Canning Vale Markets, which may be where the little snake had originated.

From the size of the individual and time of year it was found it is possible that the animal was born in suburban Perth. As the species is parthenogenic, the establishment of the species in an area can easily occur as seen in other regions of Australia and the world.

– GLEN GAIKHORST, Senior Reptile Keeper Perth Zoo, 20 Labouchere Rd, South Perth, 6151.

An overlooked record of the Malleefowl in the interior of Western Australia – Storr (1985, p 14) noted the northern limits of the Malleefowl *Leipoa ocellata* in the mid-eastern interior of Western Australia as 'north to Yeelirrie and east nearly to the Ernest Giles Range. Far eastern highlands (13 km SW Mt Palgrave)'. This brief synopsis implies a discontinuity in occurrence between Ernest Giles Range and Warburton, and this is shown on the map published in Johnstone and Storr (1998, p 35).

Between November 1895 and June 1896, S.G. Hübbe travelled from South Australia to Western Australia via Oodnadatta, seeking a well-watered stock route between South Australia and the recently discovered goldfields (Hübbe 1897).

On 9 May 1896, at lat. 26° 29' 54", 'in vegetation consisting of poor mulga, mallee, spinifex, and wiregrass [we] saw the only Lowan hen (native pheasant) seen on the trip, although we saw several of their nests and obtained eggs between the Musgrave and Everard Ranges [in South Australia].' (Hübbe 1897, p 36).

On 7 May Hübbe named Lake Gillen, on 8 May his party travelled 18 miles on a bearing of c. 222°, and on 9 May 11½ miles had been travelled (on a bearing of c. 230°) when the Malleefowl was seen. This information indicates that the Malleefowl was observed to the east of Ida Range (c. lat. 26° 30').

This record, although published by Cleland (1938, p 38), has been overlooked by WA ornithologists, presumably because it was included in a paper ostensibly concerning South Australia. Cleland fixed the location of the Malleefowl sighting as 'Near Mount Laurie and Ida Range'.

Hübbe's record marginally reduces the gap between the SW Mt Palgrave record and the main distribution of the Malleefowl by 50 km to c. 300 km.

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– IAN ABBOTT, Science Division, Department of Conservation and Land Management, Locked Bag 104, Bentley Delivery Centre, Bentley 6983.

INDEX

GENERAL

Antarctica 164
Bungendore Park, Plant Regeneration Following Fire 37
Carnarvon Range Conservation Park, Flora and Avifauna 1
Dorre Island 150
Gooseberry Hill, Red-capped Robins Breeding 195
Gregory Mathews 104
Houtman Abrolhos, Reptiles of 172
Lake Gladstone, Birds of 89
Montebello Islands, Mass Deaths of Sea Turtles 107
Porongurup National Park, Eradication of Silver Pheasant 111
Recherche Archipelago, Eastern Group, Vertebrates of 232
Rottnest Island 87, 147, 148
Torndirrup National Park, Effects of Fire 205
Walga Rock, Feral Plants and Animals 115

MAMMALS

Boodies Predating Hatchling Loggerhead Turtles 150
Dibbler feeding on *Banksia media* 250
Pseudomys hermannsburgensis 216
Recherche Archipelago, Eastern Group, Vertebrates of 232
Sandy Inland Mouse 216
Torndirrup National Park, Effects of Fire 205

BIRDS

Banded Stilt Breeding 79
Bird Usage of Planted Treebelts 179
Brown Honeyeater 247
Buff-banded Rail Breeding at Pelican Point 149
Carnarvon Range Conservation Park, Avifauna 25
Kerguelen Pintail in Antarctica 164
Malleefowl 253
Pied Cormorant, Predation on Silver Gull Chicks 135
Red-capped Robins Breeding at Gooseberry Hill 195
Red-necked Phalarope 87
Rainbow Lorikeet 88
Recherche Archipelago, Eastern Group, Vertebrates of 232
Rufous Songlark 104

Silver Pheasants at Porongurup National Park 111
Twenty-eight Parrot 88

FISH
Acentrogobius pflaumii, Introduced to Western Australia 204
Whale Shark, Body Markings 118

REPTILES
Acritoscincus trilineatum on Rottnest Island 147
Aprasia repens on Rottnest Island 148
Houtman Abrolhos, Reptiles of 172
Egernia stokesii badia, Declining Distribution 138
Loggerhead Turtle Hatchlings Predated by Boodies 150
Moloch horridus Reproduction 73
Ramphotyphlops braminus 252
Recherche Archipelago, Eastern Group, Vertebrates of 232
Sea Turtles, Mass Deaths of at Montebello Islands 107
Torndirrup National Park, Effects of Fire 205

INSECTS
Coon Bugs 201
Oxycarenus luctuosus 201
Praying mantis feeding on vertebrates 247

SPIDERS
Idiosoma sigillata, Translocation of 101

PLANTS
Carnarvon Range Conservation Park, Flora 9
Kangaroo Paws, Identification of 168
Malva dendromorpha/D. australiana Hybrids 198
Malvaceae 201
Plant Regeneration Following Fire in Bungendore Park 37
Stylidium trudgenii and *S. turleyae* 153
Torndirrup National Park, Effects of Fire 205

AUTHORS

Abbott, I. 253
Adams, M. 216
Bancroft, W.J. 147, 148, 149
Brooker, M. 195
Coate, K.H. 1, 25, 79
Cooper, N.K. 216
Cowen, S. 250
Coyle, P. 87
Dale, S. 247
Dell, J. 89, 138, 232
Desmond, A. 172
Edinger, D.C. 1, 9
Gaikhorst, G. 252
Hartley, R-C. 250
How, R.A. 138, 172
Hussey, B.M.J. 115
Irvine, L.G. 164
Johnstone, R.E. 164, 232
Kenneally, K.F. 153
Kloot, T. 104
Kendrick, P.G. 107
Lamont, C.R. 135
Larcombe, A.N. 88
Lewis, J. 37
Martin, R.A. 118
Maryan, B. 172
Mead-Hunter, D. 204
Mees, G. 168
Pearson, D.J. 172
Prince R.I.T. 101
Rippey, E. 198, 201
Robinson, D.J. 138
Smith, L.A. 232
Smith, V. 205
Start, A.N. 111
Thomas, N.D. 151
Thompson, S.A. 73
Watkins, R. 179
Wilson, S. 118

51087

CLUB NEWS

Programme

General Meetings and Branch Meetings are held at various venues in Nedlands, Kalamunda, Rockingham and North Beach.
The Retired and Leisured Group meets on alternate Wednesdays at 10a.m.
Excursions and field days are planned from time to time and will be advertised in the Club's monthly newsletter "The Naturalist News".

THE WESTERN AUSTRALIAN NATURALIST
(Journal of the W.A. Naturalists' Club)

Editor
MR JOHN DELL

The Western Australian Naturalist publishes original data on all branches of natural science pertaining to Western Australia. Originals and two copies of manuscripts should be submitted to the Editor for review by two referees. Authors are requested to follow current editorial style. If possible, manuscripts should be submitted on an IBM compatible 3½ disk in Word format. High quality illustrations suitable for some reductions in size are preferred.

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CONTENTS

	Page
Effect of fire in Torndirrup National Park, South Coast, Western Australia. By Vic Smith	205
A molecular genetic and morphological appraisal of a distinctive form of the Sandy Inland Mouse, *Pseudomys hermannsburgensis*. By M. Adams and N.K. Cooper	216
Vertebrate Fauna of the Eastern Group, Archipelago of the Recherche, Western Australia. By L.A. Smith, R.E. Johnstone and J. Dell	232
From Field and Study:	247
Index to Volume 24	254

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